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[NOTE.—Slight errors have been corrected in the Index.]

Page			
142,	line	29,	*for* Juss. (*i.e.* B. Juss.) *read* Moehring.
147	„	13	„ *pumillia* read *pumila.*
168	„	5	from bottom, *for* Wats. *read* S. Wats.
373	„	2,	for *macanthum* read *macranthum.*
381	„	15	„ specimems *read* specimens.
383	„	24	„ L. suppl. „ L. fil. Suppl.
393	„	19	„ *spicatus* „ *spicatum.*
408	„	37	„ Antlantica *read* Atlantica.
432	„	7	„ *ramosum* read *ramosius.*

THE JOURNAL

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THE LINNEAN SOCIETY.

(BOTANY.)

Quantitative Description of Ten British Species of the Genus *Mnium*. By Professor JULIUS MACLEOD, University of Ghent. (Communicated by Prof. F. E. WEISS, D.Sc., F.L.S.)

(9 Text-figures.)

[Read 1st June, 1916.]

INTRODUCTION.

WHEN we give a specific description of an animal or a plant, we use terms, and an extensive terminology has been created for the description of the characters of living beings.

The leaves of a certain species *A* are, for instance, described as *oblong, elongate, with numerous marginal teeth and a short petiole.* Those of species *B* are *oval, short, with distant marginal teeth and a longer petiole.* So long as we compare the two descriptions in a book the difference between *A* and *B* is distinct, but when we look at the objects we begin to hesitate. The words are vague: what is, for instance, the difference between a *short* and a *longer* petiole? Moreover, we are very often puzzled by the variation of the characters. We may find in *A* leaves which are really *oblong* and other leaves which are rather *oval*, and in *B* we may find some leaves which are *oblong* or *oboval* and petioles of very different lengths.

We are told, for instance, that the *pronotum* of a certain species of

Carabus is longer than broad, and that this property is quite characteristic of the species under consideration. Measuring the length and the breadth of a dozen specimens, we find that the pronotum is *always* distinctly *broader than long*! The author of the description has been deceived by an optical illusion, the system of curved lines which limit the pronotum producing a false appearance.

Similar examples are to be found in thousands. Our method of describing animal and vegetable species has made little progress since the days of Lamarck and De Candolle. It is true our descriptions are more complete than in former times, attention being paid to characters which were unknown or neglected a century ago, but the way in which the characters are described has been little improved. The defects of the method are more seriously felt in proportion as the number of the known species becomes greater.

The result of this state of things is that it is often very difficult—in fact, impossible—to identify a specimen, even by means of the best books. Again and again species already known to science are described afresh under new names, because it was impossible to recognize them in the previously published descriptions.

Notwithstanding all this, the work accomplished by systematic botany and zoology is a very valuable one; tens of thousands of species have been exactly discriminated, for the most part by a sort of instinct, which enables the experienced systematist to recognize the species by their *facies*. The masters of descriptive science possess this instinct to an astonishing degree. The difficulty begins when a specific description is to be made.

Is it possible to adopt a better descriptive method, which would render the valuable knowledge collected by the systematists more exact, and make the inventory of living nature more useful? Is it possible to describe and to identify an animal or a vegetable species by means of numbers representing the values of the specific characters? *

Such a *quantitative method* is used for the description of inorganic objects. When we want to describe a specific mineral or a chemical substance (for instance, *quartz*, *sea-salt*, *copper*, *sulphate*, *water*, etc.), we measure a certain number of its properties, such as *density*, *index of refraction*, *coefficient of expansion*, *angles of the crystalline form*, etc. The measurements are made according to certain conventions with reference to temperature, pressure, and other conditions of observation. The description consists of figures (so-called *constants*).

* In deference to customary usage, I have used throughout the present communication the word "character" in speaking of the various features the measurements of which give us specific differences. I should have preferred the term "property" as emphasizing the analogy between the specific characters of living organisms and the various properties of inorganic objects. I hope to develop this point of view more fully in a subsequent publication.

I have tried to apply a similar method to the description of living species by measuring 38 characters of about 90 species and 20 varieties of the genus *Carabus*. For each property I have determined the minimal, median, and maximal value in each species. The figures, set in order in tables, enabled me to describe and to identify the species and varieties more accurately than by the usual method of description. Unfortunately, the war prevented me from finishing and publishing my work.

I have tried to carry out similar work with plants, in the Cryptogamic Laboratory of the University of Manchester. On the suggestion of Prof. Lang, I took mosses of the genus *Mnium*. I have measured fourteen different characters of 10 British species of this genus (altogether more than 30,000 measurements have been made). Four other species of *Mnium* belong to the British flora, but they are very rare in these islands and could not be measured for want of material.

I hope to publish later a more extensive work on the theoretical part of this quantitative method. In the present paper I confine myself to a quantitative description of the ten studied species, giving only the theoretical indications which are necessary to make the given descriptions comprehensible.

I read a short abstract of my work at the Meeting of the British Association for the Advancement of Science, in Manchester, on September 7th, 1915 *. I may perhaps be allowed to reply here in a few words to some remarks which were made on that occasion.

The first criticism was to the effect that I was using a rather complicated method for the identification of species which are easily distinguished by every student of British mosses. I give the description of British species of *Mnium* as a first example of the application of the quantitative method, because I wanted to begin with *well-known, easily recognizable* species, in order to put the method to the test and to establish a starting-point for further application.

Secondly, it was said that the use of the method is too laborious to allow of an extensive application. It is true that the quantitative description of a certain number of species is a long and rather tedious task, but this is not a sufficient reason to cause us to be discouraged. When the descriptions and the tables of identification are made (once for all), the measurements which are needed for the identification of a given specimen of *Mnium* may be made in less than an hour, and for the use of the tables no more than about ten minutes are needed. Let us remember that the exact measurement of one single physical constant is also a delicate and sometimes a very long task.

* "On the Expression by Measurement of Specific Characters, with Special Reference to Mosses," Report of the Meeting of the British Association for the Advancement of Science, held at Manchester in September 1915.

Despite this fact, innumerable constants have been determined by physicists and chemists. In a modern Dictionary of Chemistry we find hundreds of thousands of numbers which have been calculated during more than a century. Many of them (for instance, the atomic weight of the elements) were *at the beginning only approximate and have been corrected later on.* It is certainly possible to carry out a similar work with animals and plants.

My address seems to have made on some persons the impression that I am complicating things which are rather simple. In reality, the method enables us to face and to surmount difficulties which *actually exist* and are ordinarily overlooked. When we are told, for instance, that in *Mnium rostratum* the cells of the leaves are larger than in *Mnium serratum*, this information is *on the whole* correct. But we may find specimens of *rostratum* the cells of which are really smaller than those of certain specimens of *serratum*! Such facts bring about hesitation and doubt. When we say that *the breadth of the cells at the place of the greatest breadth of the leaf, in the longest leaf of a fertile stem of M. serratum*, varies between 16 and 26 μ, and that the same character varies in *rostratum* between 22 and 36 μ, we have replaced, it is true, a simple notion by a complicated one, but the given information is complete. The student is no longer disconcerted by the disagreement between the descriptive text and the facts he is observing.

The material used for obtaining the measurements that follow was for the most part obtained from the Barker collection of British Bryophytes.

This herbarium was given to the University of Manchester by the late Thomas Barker, Professor of Mathematics, who was the founder of the Chair of Cryptogamic Botany in the University of Manchester.

A few specimens were taken from the Manchester Herbarium. A number of rare specimens were kindly given to me by Mr. H. N. Dixon, M.A., F.L.S., to whom I offer here my best thanks.

To Prof. W. H. Lang, in whose laboratory the present work was carried out, and to Prof. F. E. Weiss I am deeply indebted, as they made this work possible for me, and I wish to express to them my gratitude.

I beg Prof. G. Unwin, who kindly helped me with reference to the language, to accept my most sincere thanks.

PART I.

Gradation.

Variation of a Given Character along a Given Axis.—Variation within the Limits of One Specimen.

§ 1. Difficulties.—When we try to apply the quantitative method to the description of an animal or a vegetable species, we meet two serious difficulties.

The first difficulty depends on the individual variation. The great majority of the characters of animals and plants are variable within the limits of each species, and the differences between several individuals of the same species are often great. When we measure, for instance, the *length* and the *breadth* of the *pronotum* (*prothorax*) and the *elytra* of a dozen Beetles (Coleoptera) between which there is no specific difference, we see that they are all different from each other in the four characters under consideration; and one who makes for the first time such a series of measurements is astonished by the importance of the observed differences, although the measured specimens seemed to be, at first sight, almost identical. The figures seem to vary in a most capricious way, and to be useless for the description of a species or the identification of a specimen. In the description of living beings, quantitative data have been used only in those rather exceptional cases in which a character is not (or only very slightly) variable (examples: number of teeth of the peristome of the Mosses, number of stamens and styles in many flowers, etc.). We shall see further (Part II.) how it is possible to use even such variable figures for description and identification.

The second difficulty occurs especially in the Vegetable Kingdom and in polypiform animals; also to a certain degree in other animals. It is the result of a peculiar sort of variation which is quite distinct from the individual variation (or variation properly so-called), and may be called gradation.

Example: Let us suppose that we want to compare the length of the leaves in two species of plants, A and B. Enormous differences are almost always observed between the leaves of each specimen. In one fertile stem of *Mnium orthorrhynchum*, with 53 leaves, the shortest leaf had a length of 0·46 mm., the length of the longest leaf was 3·91 mm. In a similar stem of *M. undulatum*, with 51 leaves, the length of the longest leaf was 8·97 mm., that of the shortest leaf 1·06 mm.* What answer can be given

* In a branch of *Ulmus montana* with seven leaves the length of the longest leaf (petiole + limb) was 15·5 cm., that of the shortest leaf 6 cm.

when we are asked what is the length of the leaves of a specimen of *Mnium orthorrhynchum* or *Mn. undulatum?* To find the answer, we want to establish the conditions under which the measurements are to be made in order to obtain comparable figures. In other words, when we have measured a leaf *l* belonging to a specimen of the species A, we want to find in a specimen of the species B a leaf which is comparable with *l*.

§ 2. Gradation.—The way in which it is possible to solve this problem may be indicated by the study of an example.

We take the Mosses of the genus *Mnium*. All the species belong to the ordinary type of the Acrocarpic Mosses. In a complete specimen we find fertile stems (which bear a fruit) and, according to the species, erect and horizontal sterile branches, male branches, etc. The leaves of all those branches are more or less different from each other in all the specimens of a given species. We agree, therefore, to limit our measurements to certain definite and restricted features, in the same way as we do when we measure the properties of inorganic objects. We select the *fertile stem*, and exclude all the other parts of the plant. The fertile stems may be considered as comparable in all the specimens and all the species.

When we measure, for instance, the length of all the successive leaves of such a stem from the base to the summit, we see that the character *length* increases up to a maximum and then diminishes (see Table I.).

Table I.

Mnium punctatum, Hedw.: a fertile stem with 10 leaves; length of the successive leaves in mm.

Leaves:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length	0·97	1·31	2·42	4·15	5·37	6·44	7·13	7·12	6·39	2·46

Here we have a first simple example of gradation. Gradation is the variation of a given property along a given axis. In this case the *axis of gradation* or *line of gradation* is the longitudinal axis of the stem which bears the measured leaves. We know that those leaves have been developed successively in acropetal order; therefore the whole system of ten leaves represents a period of growth, and at the same time a *period of gradation* of the character under consideration.

By means of the figures in Table I. we may construct the *Gradation Curve* of one specimen (*specimen curve*), in which the axis is represented by a horizontal line, the length of the successive leaves being represented by equidistant vertical ordinates (fig. 1). A *specimen curve* is merely a graphic representation of facts, without any calculation.

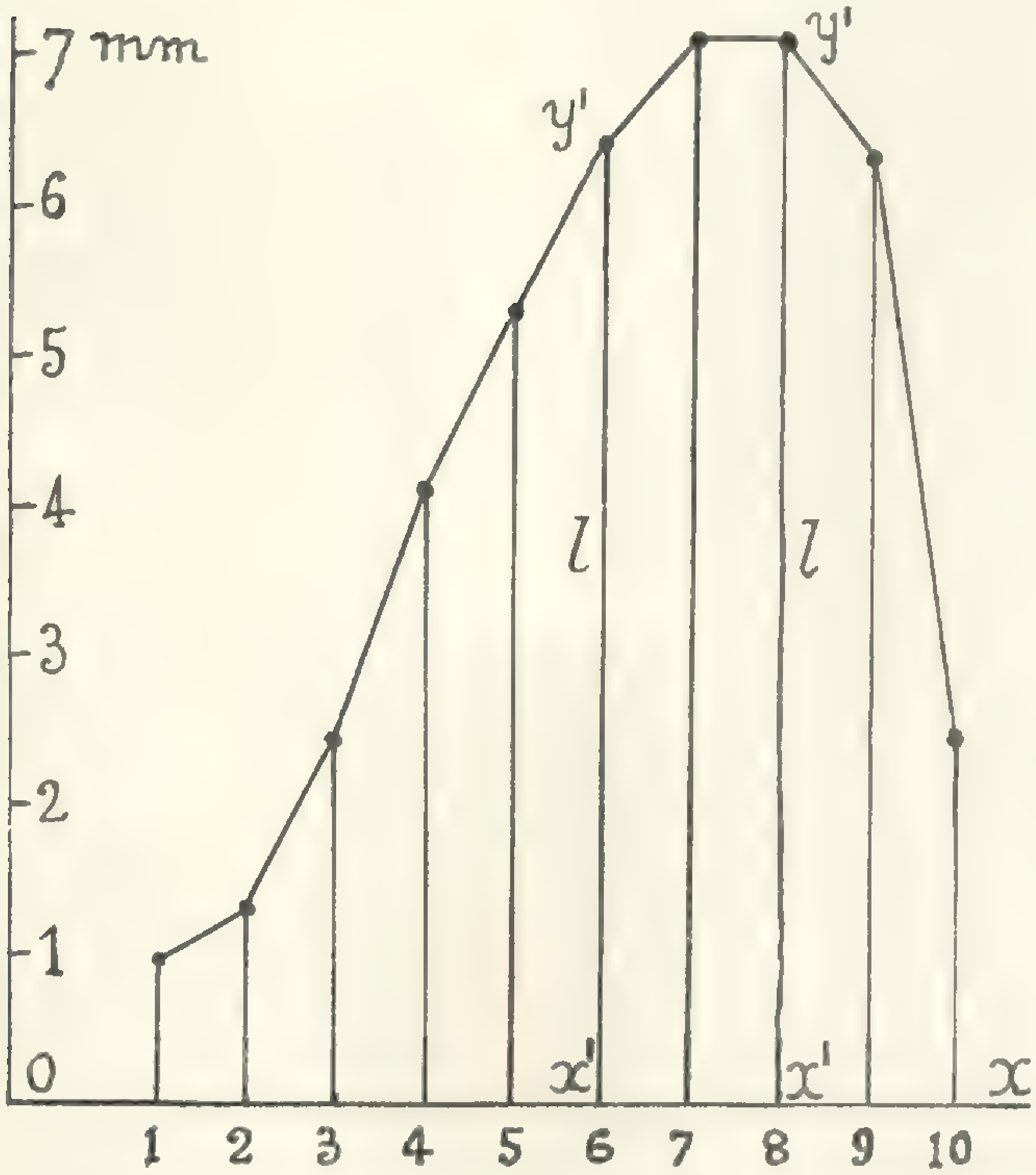

FIG. 1.—*Mnium punctatum.* Gradation Curve of the length of the leaves of one fertile stem. *o*, Base of the stem; *x*, Summit of the stem; 1, 2, . . . 10, successive leaves. Scale in mm. See the figures in Table I.

At first sight a gradation curve * recalls by its ascending-descending form a variation curve properly so-called; it is, however, something quite different. In the ordinary (individual) variation, the differences between the individuals depend on CHANCE. A variation curve properly so-called represents the distribution of the observed values of a given property among

* Percy Groom, "Longitudinal Symmetry in Phanerogamia," Phil. Trans. Roy. Soc. London, ser. B, vol. cc. (1908) pp. 57–115, with numerous figures.

Percy Groom measured the length of the successive internodes of the stem in a number of Phanerogams (*Rhinanthus*, Chenopodiaceæ, Boraginaceæ, Solanaceæ, *Lysimachia*, *Scrophularia*, *Ampelopsis*, etc.). In his paper one finds numerous internode-curves which represent the variation of the length of the internodes along the axis, in the same way as our fig. 1 represents the variation of the length of the leaves. By the study of what I call Gradation, Percy Groom was brought to interesting morphological conclusions—among others, "*that the alternate-leaved Chenopodiaceæ have a phyllotaxis transitional between alternate and opposite, and that opposite phyllotaxis is primitive in this family.*" (*Loc. cit.* p. 65.)

From this example one sees that the study of gradation may render good service in a field of research quite different from the subject of the present paper on Mosses.

a certain number of comparable individuals. The form of such a curve is governed by the laws of chance (Quetelet, Galton).

The Gradation (variation along an axis) does not depend on chance, but on a certain cause (force or factor) which varies regularly all along the axis according to a certain law which is quite different from the laws of chance. In other words, in our example (fig. 1), the length y' of a given leaf l depends on (is a function of) the distance x' between the base of the leaf l and the origin o of the axis *. Chance has only an influence in producing slight *irregularities* of the curve, which are easily discerned when the curve is drawn. In fig. 1 such irregularities are less conspicuous than in the majority of the gradation curves (fig. 2).

§ 3. Importance of the longest leaf.—In the fertile stem of all the species of *Mnium* the gradation curve of the length of the leaves is in a certain degree variable, but on the whole similar to the example represented in fig. 1. The longest leaf of a given fertile stem (corresponding to the summit of the curve) is therefore comparable with the longest leaf of any fertile stem of any species of *Mnium* whatever (see § 12, Remark II.).

§ 4. Simultaneous Gradation of several characters along the same axis.—When we measure a second character (for instance, the *breadth* of the successive leaves of a fertile stem) we obtain a second gradation curve.—*Example* : The gradation of the character *length* and the character *breadth* of the leaves of a fertile stem of *Mnium serratum* ; see Table II. and fig. 2.

Table II.

Mnium serratum, Schrad. : a fertile stem with 27 leaves ; length and breadth of the successive leaves in mm.

Leaves:	1.	2.	3.	4.	5.	6.	7.	8.	9.
Length	..	1·66	1·86	2·06	2·15	2·28	2·42	2·44	2·44
Breadth	..	..	..	1·06	1·09	1·17	1·17	1·18	1·15
Leaves:	10.	11.	12.	13.	14.	15.	16.	17.	18.
Length	2·71	2·64	2·86	3·02	2·95	3·19	3·09	3·24	3·40
Breadth	1·36	1·27	1·35	1·34	1·29	..	1·46	1·52	1·51
Leaves:	19.	20.	21.	22.	23.	24.	25.	26.	27.
Length	3·28	3·55	3·70	3·84	4·68	4·37	4·71	4·02	3·22
Breadth	1·42	1·44	1·49	1·46	1·27	1·24	1·07	0·80	0·55

Here the two characters are independent of each other with reference to their gradation: the maximal *length* corresponds to leaf 25, the maximal *breadth* to leaf 17.

* The relation between the value y and the distance x may be expressed by $y=fx$. The nature of f is hitherto unknown.

I have studied the gradation of twelve characters of the leaves in ten species: the figures are given in the description of the species, Part IV. The general conclusion is that in each species *each character has its own gradation,* different from all others. (There is, however, often a certain analogy between certain gradation curves. See *Types of gradation,* § 11.)

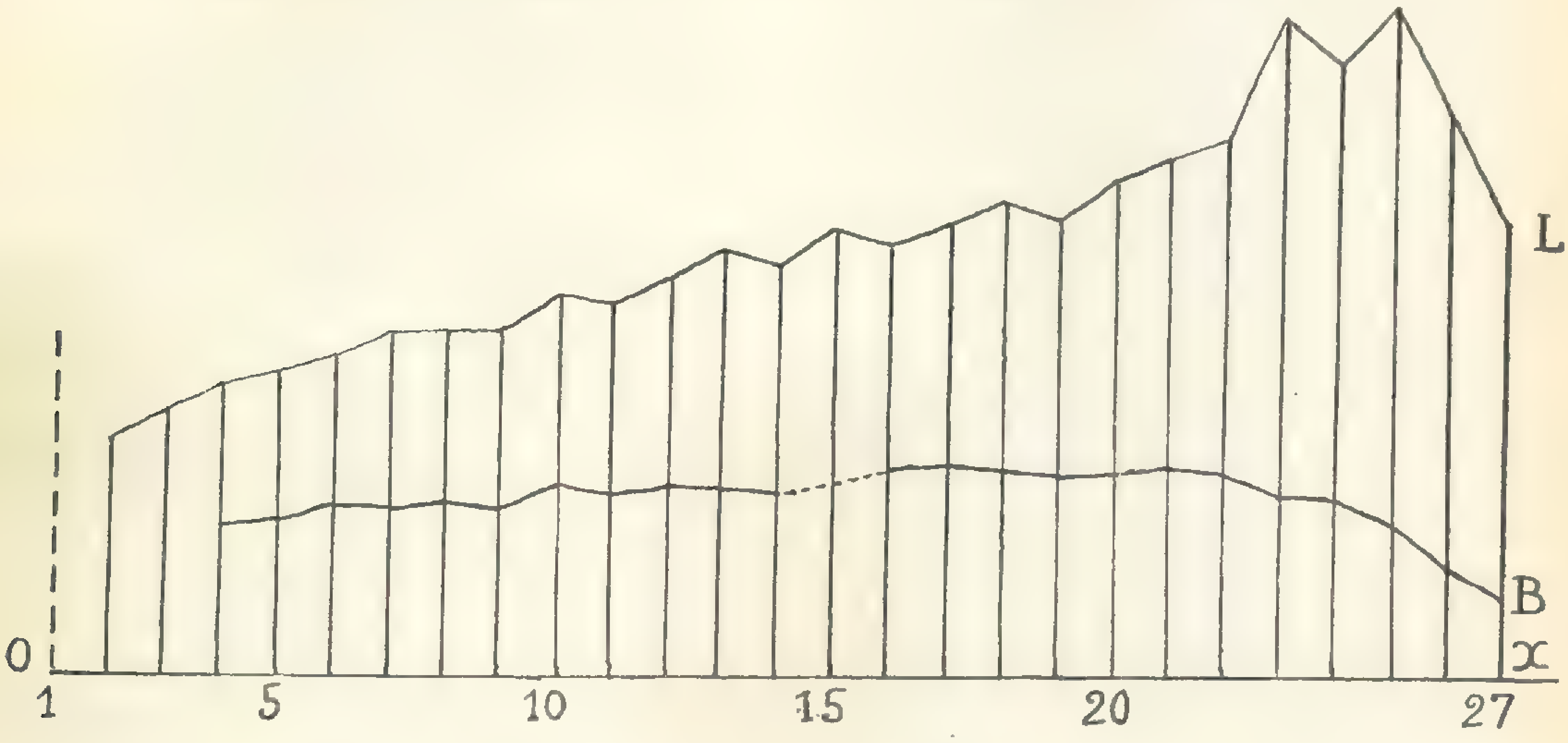

FIG. 2.—*Mnium serratum.* Gradation Curves of the *length* and the *breadth* of the leaves of one fertile stem. *o,* Base of the stem; *x,* Summit of the stem; 1, . . . 5, . . . 27, Successive leaves; *B,* Breadth; *L,* Length. See the figures in Table II.—In these curves the fortuitous irregularities produced by chance are more conspicuous than in fig. 1.

§ 4 *a.* PERIOD OF GRADATION.—So long as I was acquainted only with the gradation of the *length,* I thought that there was a relation between gradation and the so-called *grand period of growth,* the development of the longest leaf synchronising with the period of greatest velocity of growth. But the fact that each character has its own independent gradation and that there is no coincidence between the highest values of several characters of the same stem, makes it very difficult to admit such a relation. The suggestion that a connection really exists between the variation of a character along an axis and the variation of the velocity of growth along the same axis, can only be accepted when we admit that each character has its own grand period coinciding with the summit of its gradation curve. According to this view, we should no longer speak of one grand period, but of as many grand periods as there are characters.

Percy Groom, discussing the question of a possible connection between the grand period of growth and the normal *curve* of a main axis of a herb (gradation of the length of the internodes) has pointed out that: "*What Sachs describes as the grand period of growth of a cell involves merely a kinetic conception dealing exclusively with the velocity or rate of growth of a cell. The proposition in question . . . . does not define or treat of the duration of growth or the ultimate dimensions attained*

by a cell. . . . The length attained by an internode, on the other hand, depends upon several factors: the original length of the internode, the mean velocity and duration of its growth." (Phil. Trans. Roy. Soc. ser. B, vol. cc. (1908) p. 96.)

The question is a very complicated one (see Percy Groom, *l. c.* pp. 96–101). We do not need to discuss it further in the present paper. In any case, we may consider all the leaves which belong to *one* gradation curve as representing one continuous (uninterrupted) period of growth (period of gradation), abstaining from any reference to a possible connection between the form of the gradation curve and the variation of the *velocity of growth* during that period.

§ 5. Leading character.—When we want to study the gradation of several characters along the same axis, at first each character must be studied separately. But, in order to obtain a general view of the whole, we may take one of the characters as a *standard* or *leading character*, all the others being referred to the standard. The choice of the leading character is, in each peculiar case, arbitrary. As a rule, we may take a conspicuous character, the gradation of which is distinct. I take in this paper the length of the leaves, the curve of which has ordinarily a prominent summit.

§ 5 *a*. We may represent the gradation of a given property in four different ways, viz., by means of

1°. A curve of one specimen (*specimen curve*): this is merely an empiric representation of facts. See §§ 2 & 4.

2°. An interval curve of one specimen (*specimen interval curve*). See § 6.

3°. A *mean interval curve* of several specimens. See § 7.

4°. The curves 1°, 2°, and 3° may be brought into the form of *percentage* curves. See § 8.

§ 6. Interval curve of one specimen.—In this paper I limit myself to that part of the stem which extends from the lowest leaf to the longest one. As the number of leaves is very variable, even within the limits of one species* (which makes comparisons difficult), I divide this part of the stem into 10 equal intervals: having measured the value of a given character of all the leaves, I calculate the mean value of the character in each interval. The figures of each interval thus become comparable with the figures of the same interval in all the specimens and species. Moreover, as the leaves are brought together into groups, the small irregularities produced by chance disappear to some extent, especially when the leaves are numerous.

Example: I take the length of the leaves of the stem of *Mnium serratum*, the figures of which are given in Table II. (fig. 2). From the lowest leaf to the longest one, the number of leaves is 25. I divide this part of the

* *Examples.*—Fertile stem of *Mnium punctatum*, 7–19 leaves; fertile stem of *M. hornum*, 46–64 leaves.

stem first into 1000 grades. The leaf 1 (lowest leaf) is placed at 0°, the leaf 2 at 42° *, ... the leaf 6 at 209°, ... the leaf 25 (the longest one) at 1000°. I divide now the part of the stem under consideration into ten intervals, viz., interval 1 from 0° to 99°, interval 2 from 100° to 199°, ... interval 10 from 900° to 1000°. Table III. gives the number of leaves in each interval.

TABLE III.

A fertile stem of *Mnium serratum*, Schrad. : number of leaves in the ten intervals. Total number = 25. Compare Table II.

Intervals :	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Number of leaves ..	3	2	3	2	2	3	2	3	2	3

I calculate now the mean value of the property *length* in each interval, using the figures given in Table II. See Table IV.

TABLE IV.

Interval curve of one fertile stem of *Mnium serratum*. Mean length of the leaves † in 10 intervals, in mm.

Intervals :	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Mean length	1·76	2·10	2·38	2·58	2·75	3·05	3·17	3·41	3·77	4·59

As the curve in Table IV. represents one specimen (fertile stem), I call it a *specimen interval curve*.

§ 7. MEAN INTERVAL CURVE.—We may, in a similar way, construct the *mean* curve of a given character of a certain number of stems which were developed under the same conditions of existence. The safest way is to take stems belonging to the same patch.

Example : I have measured the lengths of all the leaves (114 in number) of 11 fertile stems of *Mnium punctatum* collected by Prof. Barker (Llanberis to Bangor, Wales). Table V. gives the number of leaves of each of them in each interval (see the method of calculation in § 6). It must be observed that in several stems the number of leaves is smaller than 10 ; even in such cases the place of each leaf is calculated by means of the general method used in § 6.

* 1000 : (25 − 1) = 41·7.

† Leaf 1 was damaged and could not be measured (see Table II.). Therefore only two leaves are taken into account in interval 1.

TABLE V.

Mnium punctatum, Hedw.: distribution of the leaves of 11 fertile stems among 10 intervals.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Stem 1	2	1	2	1	1	2	1	2	1	2
,, 2	1	..	1	..	1	..	1	..	1	1
,, 3	2	1	1	1	1	1	1	1	1	2
,, 4	2	1	1	1	1	1	1	1	1	2
,, 5	2	1	2	1	2	1	2	1	2	2
,, 6	2	1	1	2	1	1	2	1	1	2
,, 7	1	1	..	1	..	1	1	..	1	1
,, 8	1	1	1	1	..	1	1	1	1	1
,, 9	1	1	1	1	..	1	1	1	1	1
,, 10	1	1	..	1	..	1	1	..	1	1
,, 11	1	1	..	1	..	1	1	..	1	1
Total leaves in each interval	16	10	10	11	7	11	13	8	12	16

Dividing in each interval the total length of all the leaves by the number of leaves, we find the mean length in each interval: this gives the *mean interval curve* of the whole group. See Table VI.

TABLE VI.

Mean interval curve of the length of the leaves of 11 fertile stems of *Mnium punctatum*.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Mean length, in mm. . .	2·10	2·56	3·53	3·63	4·59	4·98	5·73	6·17	6·99	7·19
Id., reduced in % of the length in interval 10	29	36	49	50	64	69	80	86	97	100

§ 8. PERCENTAGE CURVES.—*Comparison between an interval curve of one specimen and a mean interval curve.* A comparison between *specimen* curves of two or several stems* is only suitable when the number of leaves is the same (see § 6); as this number is very variable, equality rarely occurs. Therefore we must have recourse to interval curves (§§ 6 & 7).

Interval curves (specimen as well as mean curves) in which absolute values are given are all comparable with each other, because they have all the same number of ordinates. In such curves, however, the *absolute* values of the characters under consideration are of secondary importance; the relative values of the successive ordinates, indicating *the variation along the axis*, are much more important (see also § 14). Therefore we are allowed to bring the

* Belonging to the same species or to different species.

interval curves to such a form that the absolute values are eliminated, only the relative values (proportions) being retained. This method enables us to reduce all the curves to the same scale; this makes the comparisons much easier.

In all the interval curves we suppose the mean value of the 10th interval =100, and calculate the value of the other intervals in hundreds of the 10th one. We call such curves percentage interval curves or *percentage curves* (°/₀ curves).

Example: We want to compare a mean interval curve of a group of specimens with the curve of one of the specimens. In Table VII. we give the mean curve of the length of the leaves * of eight stems of *Mnium hornum* (belonging to the same patch) and the individual curve of *one* of those stems taken at random, with the corresponding percentage curves.

TABLE VII.

Mnium hornum, Linn.—Length of the leaves: mean curve of eight stems and one individual curve, with the corresponding percentage curves.

	Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
8 stems:	length, in mm. ..	2·00	2·51	2·90	3·28	3·75	4·23	4·65	5·24	6·01	6·79
	Percentage	30	37	43	48	55	62	69	77	89	100
1 stem:	length, in mm. ..	2·05	2·53	2·81	3·39	4·13	4·45	4·94	5·64	6·43	7·16
	Percentage	29	35	39	47	58	62	69	79	90	100

Comparing the percentage curves, we see that the individual curve does not deviate much from the mean curve. This is an ordinary rule: in the great majority of the cases the gradation of a given character in a stem follows more or less approximately the *mean* curve of the *group* of stems to which it belongs. Therefore we may admit that a mean curve is not the result of an arbitrary method of computation, but that it has a real significance. A mean curve represents the most probable (approximately the most frequent) gradation in a group of stems. The differences between the specimen curves are very likely produced by chance—in the same way as the ordinary individual variation.

§ 9. PERCENTAGE CURVES (continued).—*Comparison between two species with reference to the gradation of the same property.* Let us compare, for instance, the mean percentage curve in Table VII. (*M. hornum*) with the similar curve in Table VI. (*M. punctatum*). The difference between both curves is obvious—too great to be explained by chance. In the intervals 7, 8, 9 the percentage values are much higher in *punctatum* than in *hornum*: the result is that the summit (interval 10) is distinctly more prominent in *hornum*. (See also Table IX.)

* 340 leaves distributed among 10 intervals.

§ 10. PERCENTAGE CURVES (continued).—*Comparison between several characters of the same species.* Table VIII. enables us to compare the gradation of four characters of the leaves of *M. hornum* by means of their mean percentage curves (eight specimens belonging to the same patch). The absolute values are given in the descriptive table of *M. hornum.*

TABLE VIII.

Mnium hornum, Linn.—Mean percentage curves of the gradation of four characters. Eight stems (340 leaves). See fig. 3.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length	30	37	43	48	55	62	69	77	89	100
Breadth	45	53	63	77	94	107	111	120	121	100
Number of cells at the place of the greatest breadth	60	67	76	90	103	114	119	124	124	100
Breadth of those cells	67	72	78	83	89	94	94	94	100	100

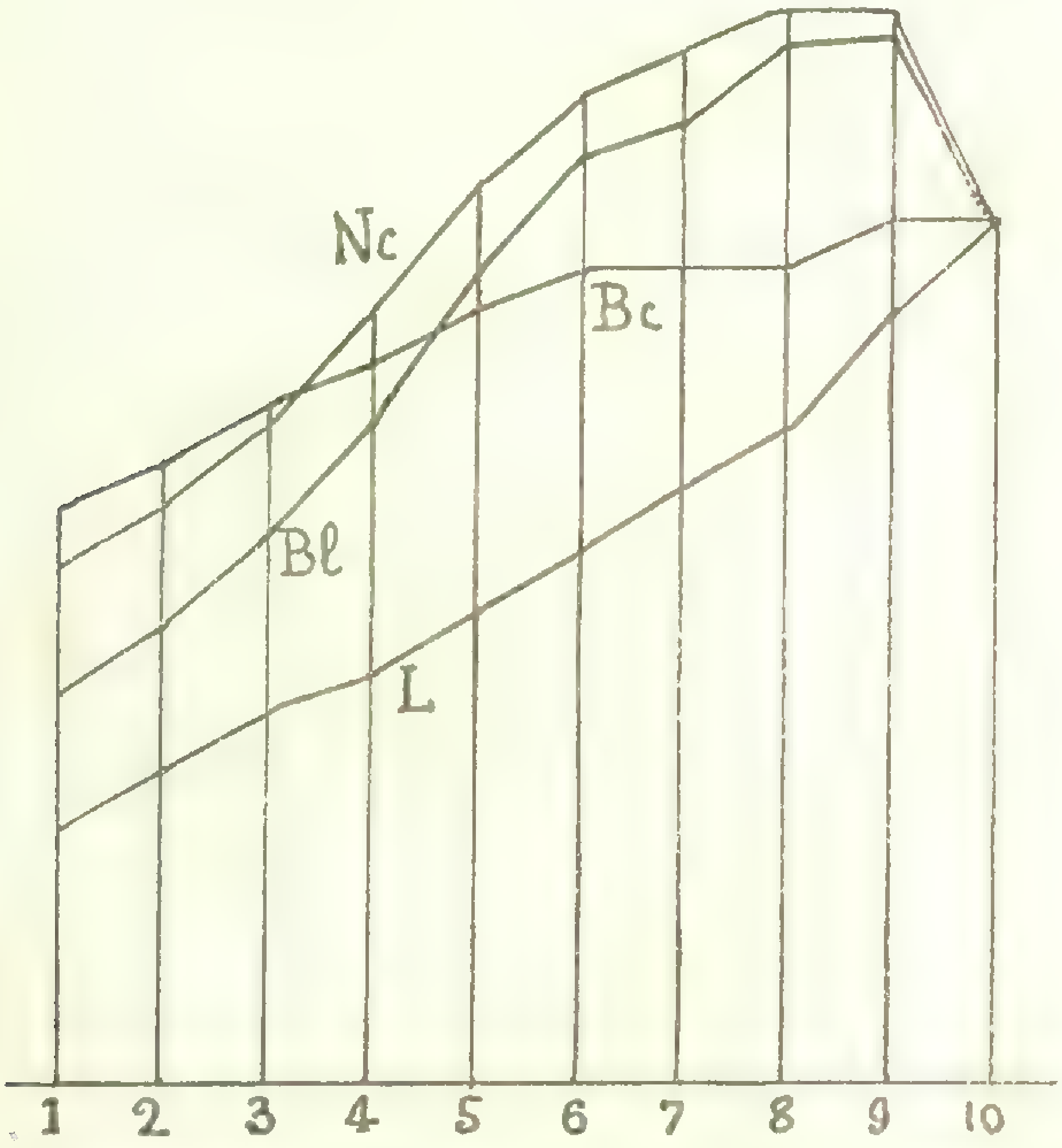

FIG. 3.—The curves represent the figures in Table VIII. *L*, length of the leaves; *Bl*, breadth of the leaves; *Nc*, number of cells; *Bc*, breadth of the cells.

We see here (fig. 3) more examples of the independence of the gradation curves; the curves *L*, *Bc*, and *Nc* are, indeed, quite different.

The curve *Bl* is interesting. The character *Bl* (breadth of the leaves) depends on the whole on two factors: the number of cells (in the transverse direction) and

their breadth. In the intervals 1–6 the curves *Nc* (number) and *Bc* (breadth of the cells) are both ascending; the increase of *Bl* in those intervals depends on the two mentioned factors. In the intervals 6–9, the increase of *Bc* being less rapid, the influence of this factor on the increase of *Bl* becomes smaller and this increase depends *almost* exclusively on *Nc*. In the intervals 9–10 *Bc* is invariable; therefore the variation (negative increase) of *Bl* depends *merely* on the variation of *Nc*.

The relations between *Bl* and the factors *Bc* and *Nc* are thus variable all along the axis. Moreover, those relations are not the same in all the species. If we try to study those relations by taking a number of leaves at random, we may be brought to contradictory results, and general conclusions drawn from such fragmentary observations may be rather illusory. It is merely by the study of the gradation curves in a sufficient number of species that we may hope to discover general rules governing the relations between the dimensions of an organ, the number of its constituent cells, and their dimensions*.

We see from this example that the knowledge of the gradation may have a certain importance for the solution of certain physiological and morphological problems—apart from its significance for the study of species and their variation.

§ 11. Types of Gradation.—The gradation curves of twelve characters of the leaves of the fertile stem in ten species of *Mnium* may be brought roughly under five types:—

Type I.: The character under consideration increases from the lowest leaf to the longest one, and decreases beyond this. This is, of course, the case with the length of the leaves (leading property) in all the species, and also in some other cases (*examples*: figs. 1 & 2; *L* and *Bc* in fig. 3; *Mn. rostratum* and *subglobosum* in Table IX.).

Type II.: The character, increasing from the lowest leaf, reaches its maximum (summit of the curve) below the longest leaf, the position of the maximum being very variable. See, for instance *Nc* and *Bl* in fig. 3. More examples are given in Table IX.; in this table the summit of the curve of the same character (breadth of the leaves at their base) has a different position according to the species. Two species have their summit in interval 10: these belong thus to Type I. The eight other species (*hornum* is doubtful) belong to Type II., the summit being situated below the longest leaf.

A comparison between the curves in Table IX. is the occasion of some interesting remarks. We see, for instance, that in two species (*rostratum*, *subglobosum*) the longest leaves have the broadest base, but in four other species (*affine*, *cuspidatum*, *undulatum*, *punctatum*) the longest leaves have the *narrowest* base. In *subglobosum* the shortest leaves (intervals 1, 2) are much narrower at their base than the longer ones (intervals 9, 10); in *punctatum* we see rather the inverse. This is interesting, because these two species resemble each other in many other characters.

* See Percy Groom, Phil. Trans. Roy. Soc. London, ser. B, vol. cc. (1908) pp. 96–98.

TABLE IX.

Mean percentage curves of the *breadth of the leaves at their base* in ten species of *Mnium*. The absolute values (in mm.) are given in the descriptive tables of the species. Each species is represented by one patch.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
affine	117	126	139	131	124	127	119	104	97	100
cuspidatum	107	127	132	133	132	127	126	116	106	100
hornum	59	67	73	81	87	90	92	96	101	100
orthorrhynchum	79	84	92	96	104	122	124	118	105	100
undulatum	105	110	128	145	143	135	134	122	114	100
rostratum	65	70	68	73	70	71	77	78	90	100
spinosum	90	106	127	122	122	113	106	103	100	100
punctatum	103	111	114	113	114	109	112	110	105	100
subglobosum	72	83	94	94	89	95	88	92	98	100
serratum	91	97	98	103	108	114	115	110	100	100

TYPE III.: In some curves the increase is rapid in the first intervals; when a certain value is reached it remains *constant* or *almost constant* in the next intervals, the curve assuming the form of a horizontal line.—*Examples*: The number of cells at the place of the greatest breadth of the leaves in *M. undulatum* (almost constant in intervals 4–10) and also *M. spinosum* (intervals 4–8). See Table X., in which the curve of a third species is given for comparison.

TABLE X.

Mean interval curves of the number of cells of the leaves at the place of the greatest breadth in three species of *Mnium*. Absolute values.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
undulatum	63	71	76	91	92	89	91	90	89	89
spinosum	40	59	84	91	91	90	88	88	87	82
orthorrhynchum	28	32	37	40	46	53	60	60	52	42

TYPE IV.: In some specimens and in some species a character has the value 0 (does not exist) in the first intervals.—*Example*: In the great majority of the specimens of *Mnium hornum* the teeth at the margin of the leaves and on the vein (at the back of the leaf) do not exist in the lowest leaves. See Table XI.

TABLE XI.

Mnium hornum.—Gradation of the number of teeth (1) at the margin of the leaves and (2) on the nerve. One stem; interval curves.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Teeth: margin	0	0	1	14	32	42	50	53	59	65
,, nerve	0	0	0	0·2	1	3	5	7	7	10

Type V. : Sometimes a character reaches its maximum in the leaves which are above the longest leaf.—*Example* : In *Mn. punctatum* the nerve is short and never reaches the summit of the leaf in the three first intervals ; in intervals 4–10 it grows *longer*, more and more approaching the summit and often (not always) reaching this. In the second leaf above the longest leaf, and further upwards, the nerve reaches the summit in all the specimens I have observed.

Remark : The classification of the characters in five groups with reference to their gradation is an artificial one, as all possible transitions between the types are found to exist. A common feature of all the gradation curves is their ascending-descending form. All the observed differences may be brought under two principles :—1°, the variation of the position of the summit ; 2°, the variation of the *rapidity* of increase (or decrease) along the axis. In other words, the differences between the curves are quantitative *.

§ 12.—From the examples given in the preceding paragraphs, we may conclude that the gradation of a particular series of measurements is a character in itself, independent of the absolute value of the feature under consideration. The gradation of a given character is more or less variable among the specimens of the same species (see § 8) and often very different from one species to another (see Table IX.). The gradation curve may be modified by the conditions of existence—we know at least one good example of such a modification †.

The principle of gradation rules greatly in the morphology of plants, and also in a certain degree the structure of animals (see § 23, note *, p. 33). A full discussion of this subject would go far beyond the limits of this paper. Therefore I want to close this part with five final remarks.

Remark I. : The knowledge of the gradation of a certain number of characters enables us to make clear the variation of the leaves of the same stem.—*Examples* : In fig. 2 a given leaf (for instance, 25) is quite different from another given leaf (for instance, 17) with reference to the measurements of *length* and *breadth*. As each character has its own independent curve (see figs. 2 & 3), and as much diversity exists among the curves, the result is a practically unlimited number of combinations ‡, the characters of each leaf depending on its position §. This form of variation *seems* to be of the same kind as the individual variation, but it is something quite different (see § 2).

* We may suppose that in the relation $y=fx$ (see note, § 2, p. 8) certain variable factors intervene, the knowledge of which would perhaps enable us to explain the observed differences.

† The gradation of the number of marginal florets in *Chrysanthemum carinatum*, Schousb.

‡ In Table II. the figures in each vertical column give the combination of the corresponding leaf.

§ This is also the case with branches, buds, flowers, fruits, trichomes, hydathodes, etc.

Individual variation depends on *chance*, but the variation of the twenty-seven leaves in fig. 2 is independent of it *.

The two forms of variability are often confounded, and the fruit of many laborious researches has been spoiled by that confusion.

Let us suppose that we want to study the variation of the *length* of the leaves of the fertile stem of *M. hornum* (or any other species). If we collect and measure a certain number of leaves taken at random from a certain number of stems, and if we construct a *variation* curve by means of the collected figures, we bring together material which is not homogeneous. The variation depends here on two causes—*chance* and *gradation*,—the effects of which are not governed by the same laws. If we start from the idea that variation, in this and all similar cases, is merely governed by the law of chance, the calculation of a mean value and other more complicated computations will give artificial results.

As this question is important, I may be allowed to give one more example. In Table XII. one finds the mean interval curves of four characters of the leaves of *Mnium orthorrhynchum.*

TABLE XII.

Mnium orthorrhynchum, Bruch, Schimp. & Guemb.—Mean interval curves of four characters of the leaves of the fertile stem.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length (mm.)	0·76	0·99	1·23	1·41	1·59	2·06	2·34	2·91	3·19	3·96
Breadth (mm.)	0·36	0·42	0·50	0·56	0·65	0·84	0·93	0·93	0·83	0·64
„ of the cells (μ)	11	11	12	12	13	14	14	14	14	13
Marginal teeth (number)	1	2	5	7	10	15	21	26	26	29

Although only four characters are taken into account in this example, the enormous differences existing between the leaves of the ten intervals are obvious (compare, for instance, the combination of figures in the vertical column 3 with the combination in column 8, etc.). The knowledge of the gradation curves is our leading clue among this disconcerting variation, *which does not depend on chance.*

REMARK II. : The principle of gradation enables us to answer the question, which leaf of a given specimen is comparable with a given leaf of another specimen : the leaves which are situated at the same degree of the gradation axis † are comparable.—*Example* : In a stem with 15 leaves (from the lowest leaf to the longest one) the 8th leaf (numbered from below) is at 500° (see the method of computation in § 6) ; in a stem with 33 leaves the 17th leaf is also at 500°, and is thus comparable with the 8th leaf in the first stem. In the same way, the longest leaves of all the stems are comparable, as they are all at 1000° (see § 3).

* We leave out of account the fortuitous irregularities of the curves (see § 2).

† In other words, the leaves which have the same value x (see § 2).

Unfortunately, apart from the longest leaf, this exact method is only applicable in exceptional cases. In a stem with 38 leaves, for instance, we do not find any leaf at 500°, and there is thus no leaf *strictly* comparable with the two former ones. A similar difficulty very often occurs.

Therefore, if we want to study the *individual* variation and to construct a *variation curve properly so-called,* we must content ourselves with collecting and measuring the leaves which belong to the same interval in each stem. In this way the variation produced by gradation is eliminated, and we may consider the obtained variation curve as being governed only by the laws of chance. The easiest method is to limit ourselves to the 10th interval. This method is not quite accurate, because the leaves which belong to the same interval are not *exactly* at the same degree : but it is approximate enough for our purpose, which is the description of species and the identification of specimens. If we wanted to be more accurate for any other purpose, we should take in each stem the longest leaf only.

Remark III. : It is obvious that certain relations exist between the characters of a given leaf and those of all other leaves.—*Example* : In Table XII. the leaves in intervals 5 and 10 have almost exactly the same breadth. Starting from this equality, we find that

In interval 10 :
Length $=3{\cdot}96$ mm. ; breadth of the cells $=13\ \mu$; number of marginal teeth $=29$.

In interval 5 :
Length $=1{\cdot}59$ mm. ; breadth of the cells $=13\ \mu$; number of marginal teeth $=10$.

The proportions interval 5 : interval 10 are

Breadth	0·65 : 0·64	=	102 : 100
Length	1·59 : 3·96	=	40 : 100
Breadth of cells	13 : 13	=	100 : 100
Number of teeth	10 : 29	=	34 : 100

Numerous comparisons of the same kind are possible : the results *seem* to be capricious to such a degree that one would think that any attempt to discover any rule whatever would be vain. All similar relations between the leaves of a given stem depend, however, on the *gradation* of the characters under consideration.

If we want to study the correlation between the leaves of several stems of the same species, we must compare leaves which belong to the same interval (in preference the 10th) or the longest leaf in all the stems, in order to eliminate the influence of gradation. The same method enables us to study the correlation between the characters of distinct species.

Tables such as Tables II., VIII., XI., XII., and the specific tables B which are given in Part IV., are, in a certain sense, correlation tables. Without taking into account the principle of gradation, it is hardly possible to make

clear correlation in the Vegetable Kingdom. The limits of this paper do not allow a further discussion of this subject.

REMARK IV.: Gradation may produce, *within the limits of one specimen*, a segregation (disjunction) of characters, which recalls the segregation occurring in Mendelian hybrids.—*Example*: Adopting the well-known *presence-absence* principle with reference to the visible properties, we consider three properties of the leaves of *Mnium hornum* :—

(*a*) In some leaves the vein reaches the summit of the leaf: we call this character S. In other leaves of the same stem it does not reach the summit (absence of the character): we call this *s*.

(*b*) Some leaves have marginal teeth: we call this character B. The absence of teeth, which is observed in other leaves of the same stem, is called *b*.

(*c*) The presence of teeth on the nerve at the back of the leaf is called N. In some leaves of the same stem those teeth are absent; their absence is called *n*.

Table XIII. gives the gradation of the three properties in *one* stem taken at random, only with reference to *presence-absence*. (See also Table XI.)

TABLE XIII.

Mnium hornum, Linn.—Presence-absence table of three characters in the leaves of one stem. Interval table.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
S–*s*	*s*	*s*	*s*	*s*	*s*	*s*	*s*	*s*	S	S
B–*b*	*b*	*b*	B	B	B	B	B	B	B	B
N–*n*	*n*	*n*	*n*	N	N	N	N	N	N	N

Let us suppose now that a species SBN (in all the leaves: midrib reaching the summit, teeth at the margin, teeth on the nerve) is crossed with a species *sbn* (nerve ceasing below the summit; margin and nerve without teeth). If the transmission of the properties happens regularly according to the *Law of Mendel*, the plants F_2 (second hybrid generation) are of eight different kinds, viz.:

SBN,	SB*n*,	S*bn*,	*sbn*.
	S*b*N,	*s*B*n*,	
	*s*BN,	*sb*N,	

Of those eight combinations, four occur among the leaves of the stem in Table XIII., viz.:

In intervals 1–2 .... *sbn*.
,, interval 3 .... *s*B*n*.
,, intervals 4–8 .... *s*BN.
,, ,, 9–10................ SBN.

It may be pointed out that it is impossible to find the explanation of those facts in the ordinary hypotheses of the *Mendelian theory*—such as the principle of segregation of the zygotes, the dominant-regressive principle, the hypothesis of the hereditary factors, and the presence-absence theory with reference to these factors,—because all the leaves in Table XIII. belong to *one* stem. Here the base of the explanation is found in a quite different principle—*gradation*. This calls for reflection *.

Remark V.: We have seen (§ 12) that the gradation of a given character is a character in itself. It would be interesting to observe the transmission of a gradation curve in hybridization. We see, for instance, in Table IX. (p. 16) that in *M. rostratum* the gradation curve of the *breadth of the leaves at their base* has its summit in interval 10; the summit of the corresponding curve of *M. spinosum* is found in interval 3. What would be the form of the curve in the hybrids between the two species?

Hybridization of Mosses seems to be impracticable; but it is certainly possible to find among the Phanerogams two species different from each other by the form of the gradation curve of a given character and suitable for experiment.

PART II.

Individual Variation.

The Use of Figures for the Description of Species and the Identification of Specimens.

§ 13. Individual variation.—Let us suppose that we have measured a given character of the longest leaf of a certain number of specimens (fertile stems) belonging to a given species of *Mnium*—for instance, the length of the longest leaf of eight stems of *M. spinosum*. In this example the figures were (in mm.):

6·55 6·68 7·23 7·53 7·64 7·64 7·68 8·10

As all the measured leaves are exactly comparable (see § 12, Remark II.), the influence of gradation is eliminated. Here the variation is governed by the laws of chance; it is *individual variation*. What answer will be given when we are asked which value is characteristic for the species?

Here we meet the first difficulty mentioned in § 1.

§ 14. Mean value.—According to the classic method, we might calculate the *mean value* (in the above example, 7·38 mm.) and take this as a characteristic one. But the significance of a mean value, and especially its

* See on the general importance of gradation, § 12, p. 17, second paragraph.

biological significance, is something VERY VARIABLE and therefore rather vague.

When we want to construct, for instance, a *mean* interval curve of a certain character of a group of specimens (see § 7), we need to find the *relative* value of the ten ordinates. As the variation of the character within the limits of a given interval depends (almost entirely) on chance, the mean value in an interval *a* is approximately the most probable (the most frequent) value of the character in the middle of *a*. Taking the mean values of the ten intervals, we eliminate as much as possible the influence of chance; the differences between the ten figures depend (almost entirely) on the influence of gradation. The construction of a mean interval curve (in which the ten mean values are used) is thus justified; such a curve gives us, by the *relative* values of its ordinates, an adequate representation of the variation of the character along the axis. But the *absolute* values of the mean values (ordinates) are of secondary importance, because those absolute values vary from one patch to another. (See the construction of *percentage* interval curves, in which the absolute values are eliminated, § 8.)

We see from this example that, when we want to use mean values, their real significance ought to be exactly defined in each peculiar case.

What is, for instance, the significance of the mean length 7·38 mm., calculated by means of the eight figures in § 13? As the variation of these eight figures depends merely on chance, the calculation of a mean value is justified from a mathematical standpoint. But its significance is limited to the patch to which the eight stems belong; similar values may be useful for the comparison of several patches with each other *, but they are not characteristic for the species.

It is, in fact, IMPOSSIBLE *to establish the mean value of a variable character of a species.* In the above example (*M. spinosum*, § 13) the mean length of the leaves was calculated by means of specimens belonging to one patch. But when we collect several patches of the same species in different localities, each patch gives a different mean value; when we bring these values together and try to calculate in that way the mean value of the species, the result is, of course, an ARTIFICIAL one and will be *modified again and again by each new observation.*

Moreover, even if we succeeded in establishing a *specific* mean value †, this would give us little help, if any help at all, for the identification of a given specimen.—*Example*: We have found for the length of the longest leaf of *Mnium spinosum* the value 7·38; in a similar way we found for *Mnium cuspidatum* the value 4·63 mm. Let us suppose that those values were really

* For instance, with reference to the influence of different conditions of existence.

† For instance, by cultivating the species under certain conditions of existence defined by convention—a method which is practicable only in exceptional cases.

specific. As the character under consideration is variable in each species, it is impossible to say to which of the two belongs a stem, the longest leaf of which has a length intermediate between the two figures; and if the individual figure of the unknown stem is, for instance, 4 mm. or 8 mm., we can give no more than a guess at its identity.

§ 15. MAXIMAL AND MINIMAL VALUES.—In a series of measurements representing the individual variation of a given property of a species, the MAXIMAL value and (with certain restrictions) the *minimal* value have a more definite BIOLOGICAL significance than the mean value. Moreover, it is possible to find these two limits, once for all, by a sufficient number of observations. THEREFORE THE MAXIMAL AND MINIMAL VALUES ARE THE CHARACTERISTIC CONSTANTS OF THE SPECIES.

Adopting this view, I deviate from the classical principle of the mean value introduced in biometrical science by Quetelet (1846). This principle, borrowed from the *theory of errors*, is quite justified from a mathematical standpoint, and may do good service in certain cases (see § 14); but from a biological point of view a mean value is very often deceptive.

There are serious *physiological* reasons for considering the minimal and maximal limits as CONSTANTS and for ascribing to them a *definite* biological and mathematical significance. I hope to expound this subject more completely in another publication *.

§ 16. PRACTICAL USE OF THE LIMIT VALUES.—In the present paper I want to content myself by pointing out the *practical importance* of the minimal and maximal values for the description of species and the identification of specimens.

We take, as first example, the length of the leaves of the tenth interval of the fertile stem of two species, *Mnium cuspidatum* and *M. hornum*. The measurement of a certain number of specimens, belonging to patches collected in several localities, has given the following limits :—

cuspidatum	3·73 mm.	7·44 mm.
hornum	5·17 „	8·06 „

In this case the variation is transgressive; in other words, the two series (variation curves) overlap each other.

Let us suppose that we want to identify a specimen *x*, and that we are hesitating between the two mentioned species. The length of the longest leaf of *x* is 5·33 mm.; this figure being between the minimum of *hornum* and the maximum of *cuspidatum*, it is impossible to make a choice. As the examples of transgressive variability are very numerous, a similar difficulty

* I beg the reader of the present paper to accept as a postulate that the maximal value and (with certain restrictions) the minimal value are specific constants.

occurs again and again, and it seems to be insuperable. There are, however, three methods to surmount it.

The FIRST METHOD consists in trying a second character of *the same specimen x* : for instance, the *breadth* of the longest leaf, which is in our example 1·93 mm. On the other hand, the limits of the breadth are in the two species :

M. cuspidatum	1·29 mm.	3·26 mm.
M. hornum..................	0·64 „	1·46 „

Although the two specific curves are again overlapping each other, hesitation is no longer possible : *x* is *cuspidatum*.

In the above example, two measurements allow us to identify *x* *. According to my experience with *Carabus* and *Mnium*, this happens more frequently than one would think. It is, of course, often necessary to measure more than two characters of a specimen, especially when we want to make a choice between numerous species.

The SECOND METHOD is applicable when we have at our disposal *two or more specimens* which belong with certainty to the same species. This is the ordinary case with Mosses, as several stems of the same species are to be found in one patch †.—*Example* : In a patch *x*, the breadth of the longest leaf of four fertile stems was measured ; the figures were

1·19 mm. 1·15 mm. 0·95 mm. 0·67 mm.

Comparing the specific limits given above, we see that the first figure (1·19) is doubtful ; it points to *hornum*, but the difference between 1·19 and the minimum of *cuspidatum* is too small to give a decision. The second figure (1·15) is also doubtful, but the two figures together make it *probable* that the patch *x* is *hornum*. The third and the fourth figures (0·95 and 0·67) are decisive in favour of *hornum* ; the *four* stems (and the whole patch *x*) belong thus to this species.

The principle of the second method is that, in a series of specimens which certainly belong to the same species, the identification of *all* the specimens is possible if *one* of them gives a decisive figure—even if the figures of all others are not decisive.

The THIRD METHOD is applicable if *one* specimen affords opportunity of measuring a given character two or several times.

In the above example of application of the first method we limited ourselves to the measurements of the longest leaf of the fertile stem *x* which we wanted to identify ; but we may go further, and take all the leaves of the tenth interval of *x* (§ 12, Remark II.). The number of those leaves depends, of course, on the total number of leaves of the stem, as one sees in Table XIII. A.

* If we had taken at first the breadth, *one* figure would have been sufficient.

† It is, of course, necessary to ascertain that the patch is homogeneous.

Application of the third method is possible when the total number of leaves is greater than ten.

TABLE XIII. A.

Number of leaves in the tenth interval. (See the method of calculation in § 6.)

Total number of leaves (from the lowest leaf to the longest one).	Number of leaves in the tenth interval.
Less than 11	1
11-20	2
21-30	3
31-40	4
41-50	5
etc.	etc.

Example : The breadth of the leaves in the tenth interval is variable—

In *Mnium orthorrhynchum* between 0·30 and 1·03 mm.
In *Mnium serratum* „ 0·59 „ 1·31 „

We want to discover to which of the two species belongs a stem x. The number of leaves is 19; in the tenth interval we find thus two leaves. The figures of those leaves are :

Breadth : longest leaf .... 1·02 mm.
„ leaf below the longest one........ 1·26 „

The figure of the longest leaf is dubious, but the second figure (1·26) is decisive : x belongs to the species *serratum**.

§ 17. PRACTICAL USE OF THE LIMIT VALUES (continued).—I give in Part V. a certain number of tables of identification, in which are found the lowest and the highest value of the fourteen measured characters for the ten species of *Mnium* I have studied. The figures were obtained for each species by the measurement of specimens from as many localities as possible.

Let us try to identify a specimen x belonging to one of the ten mentioned species.

* It is possible to apply the third method to the identification of animals—for instance, of Beetles. A considerable difference may exist between the right and the left side of *one* specimen with reference to certain characters; it may happen that a certain figure is dubious at one side, the corresponding figure at the other side of the same specimen being decisive.

FIRST METHOD: Identification of *one* fertile stem x. The figures are:

1°. Longest leaf:	(*a*) length	4·66 mm.
" "	(*b*) breadth	1·78 "
" "	(*c*) breadth at the base	0·82 "
" "	(*d*) breadth of the cells at the place of the greatest breadth	19 μ.
" "	(*e*) number of cells at the place of the greatest breadth	88
" "	(*f*) breadth of the border at the place of the greatest breadth	37 μ.
" "	(*g*) number of cells of the border at the place of the greatest breadth	6
" "	(*h*) number of marginal teeth	41
" "	(*i*) number of double teeth at the margin	0
" "	(*j*) teeth on the nerve at the back of the leaf	0
" "	(*k*) length of the nerve *	the nerve reaches the summit of the leaf.
" "	(*l*) tooth at the summit of the leaf	exists.
2°. Number of leaves		24
3°. Number of fruits		1

The order in which the tables may be used is arbitrary. We begin with Table XXV. (length): the minimum table excludes *undulatum* and probably *affine* and *hornum*; the maximum table does not exclude any species.

Table XXVI. (breadth): the minimum table excludes *subglobosum*, *punctatum*, and probably *affine*; the maximum table excludes *orthorrhynchum*, probably *serratum*, and perhaps *hornum*.

Table XXVII. (breadth of the leaves at their base): no more species are excluded.

Table XXVIII. (breadth of the cells): the minimum table excludes *subglobosum* and *punctatum* (both already excluded), and brings confirmation of the exclusion of *affine*; no more species are excluded by the maximum table.

Table XXIX. (number of cells): no species are excluded by the minimum table; the maximum table brings confirmation of the exclusion of *serratum*, excludes *orthorrhynchum* (already excluded), and perhaps *hornum*.

Table XXX. (breadth of the border): the minimum table excludes *rostratum*, *spinosum*, and also *punctatum* and *subglobosum* (both already excluded); no species are excluded by the maximum table.

Hitherto eight species have been excluded and a ninth species (*hornum*) has been excluded three times, although not with certainty. It may be remarked that we have been prudent in excluding species, allowing a wide

* On the measurement of the character k, see § 35.

margin of error, because the REAL specific limits are probably not yet reached in this FIRST ATTEMPT of construction of minimum and maximum tables *.

We may conclude that the stem *x* is probably *cuspidatum*, perhaps *hornum*.

We take now

Table XXXI. (number of cells of the border) : no more species excluded.

Table XXXII. (number of marginal teeth) : no more species excluded.

Table XXXIII. (number of double teeth at the margin) : the exclusion of *hornum* is confirmed by the minimum table.

The stem *x* belongs thus to the species *Mnium cuspidatum*.

One may perhaps think that we ascribe too high a significance to the figures when we conclude, from rather small differences between the figures of specimen *x* and the figures in the tables, that *x* does not belong to such or such a species. One must realize, once for all, that *each* figure in the tables is a LIMIT deduced from a series of measurements, and has thus a significance quite different from that of a figure given by *one* specimen taken at random.

We may, moreover, identify specimen *x* a second time, taking the tables in the reverse order and beginning with

Table XXXVIII. (number of fruits) : the minimum table excludes perhaps *spinosum* and *undulatum* ; no species are excluded by the maximum table.

Table XXXVII. (number of leaves) : the minimum table excludes *hornum* ; no species are excluded with certainty by the maximum table.

Table XXXVI. (tooth at the summit of the longest leaf) excludes *subglobosum*.

Table XXXV. (length of the nerve) excludes no more species.

Table XXXIV. (teeth on the nerve at the back of the leaf) : the minimum table excludes *hornum* (already excluded) and probably *spinosum*. No species are excluded by the maximum table.

Table XXXIII. (number of double teeth at the leaf-margin) excludes *serratum* and *orthorrhynchum*, brings confirmation of the exclusion of *spinosum* and excludes *hornum* (already excluded). No species are excluded by the maximum table.

Table XXXII. (number of marginal teeth) : the minimum table confirms the exclusion of *undulatum*. The maximum table excludes *punctatum*, and also *subglobosum* and *serratum* (both previously excluded).

Table XXXI. (number of cells of the border) does not exclude more species.

* The figures in the tables are approximate enough to demonstrate the use of the method, but they want to be verified and corrected by more measurements. It may be remembered that many *constants*, used by physicists and chemists, were at the beginning only approximate. They have been corrected later on—often at the cost of long labour.

Table XXX. (breadth of the border): the minimum table excludes *rostratum,* perhaps *affine* (and also *subglobosum*, *spinosum*, and *punctatum* previously excluded).

Eight species are already excluded. The stem *x* is thus probaby *cuspidatum*, perhaps *affine*.

Table XXIX. (number of cells) does not give an answer.

Table XXVIII. (breadth of the cells): here the minimum table is decisive, *affine* is excluded.

The stem *x* belongs thus to the species *Mn. cuspidatum*: the first identification is confirmed (continued § 19).

§ 18. The quantitative description of one individual (bertillonage): *its value for descriptive botany and zoology.*—The description of one individual of *Mnium cuspidatum* given in § 17 * may be compared with the well-known *bertillonage*, which is the quantitative description of a person.

A bertillonage is a combination of figures obtained by the measurement of a certain number of characters of a person *n*. As a given combination practically never occurs a second time, it is characteristic of the person *n*; it enables us to differentiate *n* from any other human individual whatever, and thus to identify it.

In a similar way the quantitative description of an animal or a vegetable specimen enables us:—1°, to discover the species to which it belongs (by means of maximum and minimum tables); 2°, to differentiate it from any other living individual of the same species or of any species whatever.

I think it would be very useful to add to the description of a new species the quantitative description of a few or at least of one specimen †. By means of the *exact* information given in such a description we would be enabled to identify *later on* the described species, even if the *type* is lost.

In innumerable cases it is possible to make a sufficient number of measurements without disturbing the specimens. I succeeded in measuring 38 characters of thousands of specimens of *Carabus* mounted on needles (more than 250,000 measurements) practically without spoiling them, except in the early days when I had not yet had enough practice in the work ‡. In the case of the Mosses and other minute objects (small insects, Crustacea, flowers, etc.) one is compelled to dissect the specimens, but in case of need

* To this description the gradation curves of the characters *a–l* might have been added, but this was useless for our purpose.

† Measuring as many characters as possible.

‡ If one wants to measure precious specimens (specimens of certain species of *Carabus* have a value of 10 shillings each and even more) it is advisable to practise at first by measuring similar, but valueless objects.

it is possible to keep the measured parts in permanent microscopical preparations, glass tubes, etc.

§ 19. (Continued from § 17.) PRACTICAL USE OF THE LIMIT VALUES.—Now we want to make a trial of the SECOND METHOD of identification by means of limit tables (see § 16). We take a fertile stem *a* belonging to a patch *x*. We measure merely three characters. The figures are :—

Length of the longest leaf	6·15 mm.
Breadth „ „ „	1·15 „
„ „ „ „ at its base..........	0·75 „

We begin with Table XXV. (length) : the minimum table excludes no species with certainty, the maximum table excludes *serratum* and perhaps *orthorrhynchum.*

Table XXVI. (breadth) : the minimum table excludes *affine*, *punctatum*, *subglobosum*, and perhaps *rostratum* and *undulatum* ; the maximum table does not exclude any species.

Table XXVII. (breadth at the base) : the minimum table excludes perhaps *undulatum* ; the maximum table excludes perhaps *orthorrhynchum.*

By means of three measurements of stem *a* we were enabled to exclude four species :—*serratum*, *affine*, *punctatum*, *subglobosum*, and perhaps three more species : *rostratum*, *orthorrhynchum*, and *undulatum*.

We now take a second stem *b* of the same patch *x* ; the figures are :—

Length of the longest leaf	6·92 mm.
Breadth „ „ „	0·67 „
„ „ „ „ at its base..........	0·75 „

Table XXV. (length) : no species are excluded by the minimum table, the maximum table excludes *serratum* (previously excluded) and confirms the exclusion of *orthorrhynchum.*

Table XXVI. (breadth) : the minimum table excludes *cuspidatum*, *spinosum*, *affine* (already excluded), *punctatum* (id. id.), *subglobosum* (id. id.), and confirms the exclusion of *rostratum* and *undulatum*.

Nine species being excluded, it becomes useless to go further : the patch *x* belongs to the species *Mnium hornum* *.

Example of the use of limit tables according to the THIRD METHOD *of identification* : we take one stem *x* with 43 leaves and measure four properties of the 5 leaves which belong to the 10th interval (see Table XIII. A). The figures are given in Table XIV.

* It may be remarked that in this example it was possible to identify the patch *x* by measuring merely three properties of two leaves belonging to two stems, without taking into account any of the characters used in the classical books for the identification of *Mnium hornum.*

Table XIV.

Mnium hornum, Linn.—One stem with 43 leaves.

Characters.	Particulars of the leaves in the 10th interval.				
Breadth, leaves	1·31	1·24	1·38	0·87	1·15
„ base leaves	0·71	0·75	0·76	0·66	0·75
Marginal teeth	53	52	58	46	60
Teeth nerve	7	9	9	6	7

Table XXVI. (breadth), minimum: by means of the lowest figure of x in Table XIV. (0·87) we exclude *spinosum*, *undulatum*, *rostratum*, *affine*, *punctatum*, and *subglobosum*. Using the maximum table, we exclude *orthorrhynchum* by means of the highest figure of x (1·38).

Table XXXII. (marginal teeth), minimum: by means of the lowest value of x (46) we exclude *undulatum*, previously excluded. The maximum table enables us to exclude by means of the highest value of x (60): *punctatum*, *subglobosum*, and *orthorrhynchum* (previously excluded), and also *serratum*.

The stem x thus belongs to *hornum* or *cuspidatum*.

Table XXXIV. (teeth on the nerve): *cuspidatum* is excluded by the maximum table. The stem x thus belongs to the species *Mnium hornum*.

§ 20. Remarks on the use of numbers for the identification of specimens.—For the identification of specimens we have three methods at our disposal, each of them allowing verification of the result given by the others.

Each of the three methods affords a rather wide range of possibilities.

Applying the first method (with *one* leaf of *one* stem, see § 17) we may very often use the limit-tables in two ways, starting from the first or from the last table: this allows verification (see the example in § 17). Moreover, it is possible to measure a greater number of properties, for instance (taking the Acrocarpic Mosses as an example): the length of the so-called *fruit-stalk*, some properties of the teeth of the *peristome*, the dimensions of the ripe *spores*. A section of a fertile stem (*exactly* in the transverse direction) at the insertion of the longest leaf would furnish some more measurable properties. Of course, the practical value of the method will increase in proportion as the number of the measured properties becomes greater *.

Using the second method (see § 19) we may take more than two specimens and, in case of need, verify the result as many times as is afforded by the material at our disposal.

* I have measured 38 characters of *Carabus*. In this paper I limit myself to 14 characters of *Mnium*, because I want to avoid too long a delay in the publication of a first paper on the results of the work with which I have been occupied for many years.

The second and the third method will be useful, especially in those cases in which it is impossible to measure a great number of characters (for instance, in many Fungi, Algæ, and lower animals).

Finally, the three methods may be used at the same time.

For more than a century innumerable species have been described in several instances under different names, because the available descriptions did not allow an exact identification. The result has been an enormous waste of time and a prejudicial disorder in the synonymy. We are still going on in the same way, and it is to be feared that in the future more labour will be wasted and more disorder will arise.

Would it be too much to hope that the state of things will be improved by the exact measurement of characters and the construction of limit-tables?

PART III.

The Measurement of the Characters of the Leaves in the Genus *Mnium*.

§ 21. Exact measurements. Possible error.—The exact expression by measurement of the characters of a living being is only possible if each character is strictly *determined*. When we want to measure, for instance, the length of the leaves of a certain plant, we must know exactly which leaves are to be measured, and we must determine the significance which we ascribe to the word *length* and even to the word *leaf*.

There is something elusive in the variation of animals and plants. This variation is so great that one might be tempted to content himself with more or less approximate measurements. This would be a grievous mistake, by which the use of the quantitative method might be seriously endangered. As soon as we use the quantitative method we discover how many of our notions are rather superficial; and, as we proceed, we become more and more aware of the necessity of reaching the highest possible degree of exactitude. Errors are unavoidable, but even the *limits of error* ought to be as much as possible determined.

In order to obtain an estimate of the possible errors, I measure a given character p of an object several times; after a few days I repeat the same measurement with the same object several times. The *difference* between the highest and the lowest figure divided by 2 is the possible (positive or negative) error with reference to the character p.

All the figures given in this paper were verified at least by a second measurement.

It may be recommended to the biologist who wants to apply the quantitative method to exercise himself, by measuring some exactly known properties of inorganic objects *.

In the present Part I give the definition of all the characters I have measured, the methods of measurement, and the possible error of the figures obtained.

N.B.—In all the calculations the decimal 0·5 has been taken as 1. (*Example* : 37·5 is brought into account as 38.)

§ 22. Fertile stem.—I call *fertile stem* a stem which bears a ripe or almost ripe fruit, or at least a fruit sufficiently advanced in its development to make it certain that the leaves, even those which are inserted near the summit, are adult. Here there is no difficulty.

§ 23. Definition of the word "leaf." Number of leaves.—The lowest phyllomes of a fertile stem often differ in their facies from the true leaves which are inserted higher up : therefore they are sometimes called *scales* (for instance, in *M. hornum*). As a gradual transition exists between scales and leaves, it is impossible to find a strict limit between both : therefore I call them all *leaves* †.

On the other hand, near the summit of the stem, we find almost always some phyllomes which constitute a sort of perianth. Sometimes there is a distinct breach of continuity in the gradation between the upper *leaf* and the first phyllome of the perianth, the latter being, for instance, much smaller than the former : in such cases, no doubt exists about the limit between the true leaves and the perianth. But ordinarily the gradation between both is continuous, and we must come to an agreement as to where the limit is to be made.

Proceeding towards the summit (and neglecting the lowest leaves) we find : 1°, a certain number of leaves which belong (according to the species) to the forms represented in fig. 4, *1*, *2*, *3* (in *1* the breadth increases from the base *b* to B, and decreases further to the summit of the leaf ; in *2* the breadth increases from *b* to B′ and is constant between B′ and B ; in *3* the breadth is constant between *b* and B) ; 2°, approaching the summit we very often find the form *4* (narrowed between *b* and B) ; 3°, near the summit we find ordinarily phyllomes, the breadth of which is decreasing continuously from *b* to the summit without constriction. I give the name of *leaves* to the

* For instance : the angles of a crystal, the density of a substance, the boiling-point of a liquid, etc.

† The differences and also the transition between scales and leaves find their accurate expression in the successive figures of the gradation curves (for instance, with reference to length, breadth, number of teeth, dimensions of the cells, etc.).

forms *1*, *2*, *3*, *4*, excluding form *5*, which I consider as belonging to the perianth *.

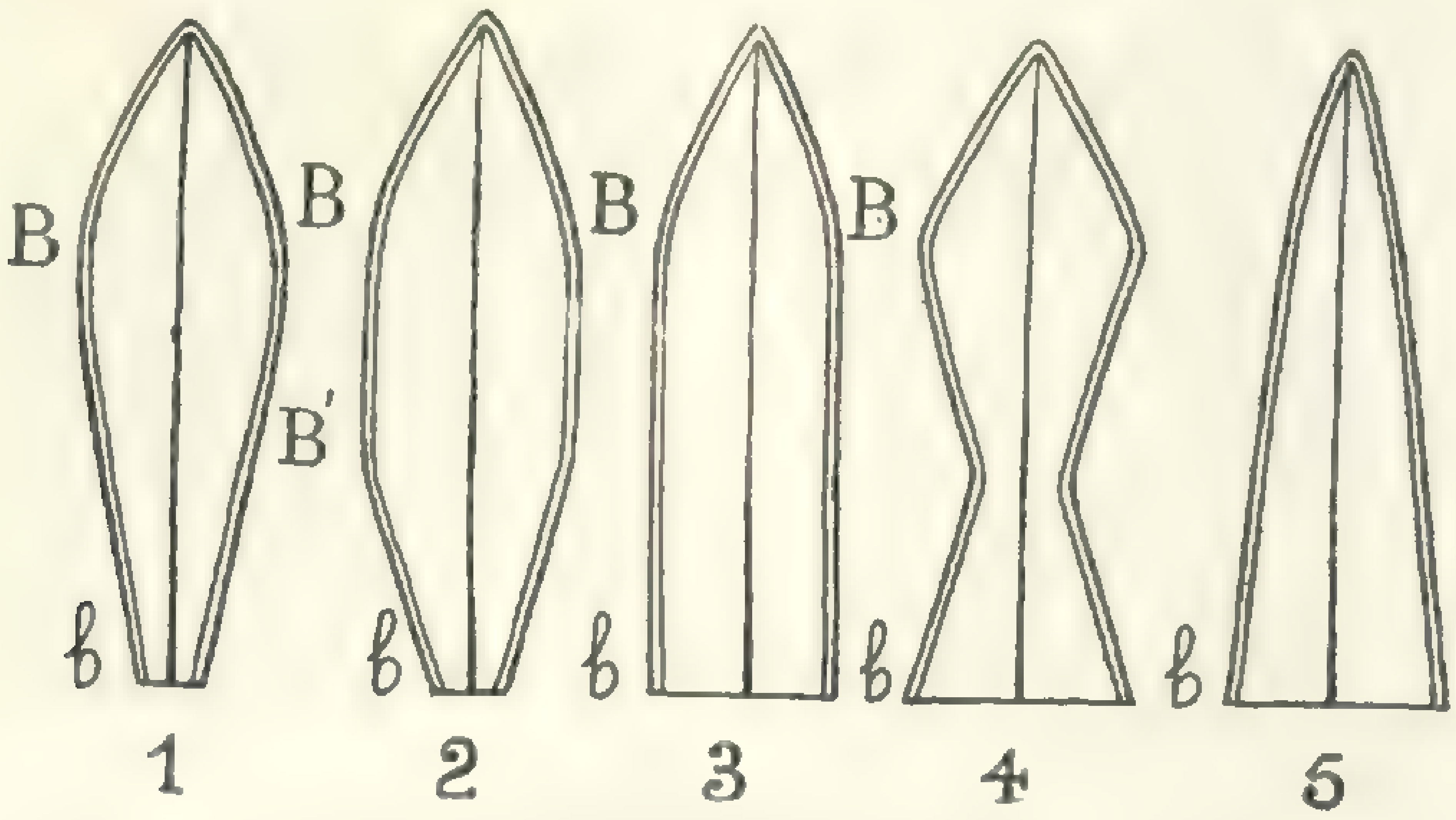

FIG. 4.—*1–4*, leaves; *5*, perianth; *b*, base. See text.

In a fertile stem several leaves near the base are usually destroyed. Therefore the number of leaves given in Table XXXVII. (page 56) includes merely the leaves *which are still in existence* when the fruit is ripe or half ripe. This error is unavoidable; it does not prevent the specific figures from being comparable with each other.

The lowest leaves being often concealed among the hairs with which the lowest part of the stem is clothed, they are to be searched for under the simple microscope, the hairs being carefully removed by means of needles. As this is a rather delicate task, owing to the small dimensions of those leaves, it may happen that some of them are overlooked. The figures given in Table XXXVII. are therefore a little below the reality. I estimate the possible error at 3 for the species with smaller figures (*punctatum*, etc.) and at 6 for the species with very numerous leaves (*undulatum*, etc.).

Some fertile stems show distinctly two *successive* periods of gradation † :

* It may be allowed to make a momentary excursion into a by-path. The breadth of a moss-phyllome varies along an axis of gradation, the direction of which is given by the nerve. The margin of the phyllome is, on each side of it, a *curve of the gradation of the breadth drawn by nature itself*. Comparing the phyllomes in fig. 4, we see that in leaf *1* the summit B of the curve is situated between the base and the summit of the leaf; in the leaves *2–3* the breadth is invariable from *b* to B (or B′ to B), and decreases further towards the summit; in phyllome *5* the summit of the curve corresponds to the base; in leaf *4* we find two summits *b* and B.

As the development of a phyllome is basipetal, its successive parts from the summit to the base have been developed successively, in a similar way as the leaves along the stem (although in reverse order). We may thus say that in the phyllomes *1*, *2*, *3*, and *5* *one* period of gradation exists, and in leaf *4* two periods are observed.

The variation of the gradation curves in fig. 4 recalls the variation of the curves in Table IX. (page 16). See § 12, second paragraph.

† This occurs rather frequently in certain species: for instance, *Mnium subglobosum* and *punctatum*. It is the ordinary rule in *Cinclidium stygium*, Sw.

the first period, including the leaves of the lower part of the stem, is suddenly interrupted at a certain level, and followed by a second period which begins with very small leaves and goes on regularly to the summit. The limit between both periods is distinctly indicated by a breach of continuity in the gradation of the length of the successive leaves.

When two periods exist, only the SECOND PERIOD (which ends at the summit of the stem) is taken into account.

§ 24. PREPARATION OF THE LEAVES.—Herbarium specimens and alcohol material, having been placed in hot water for a few minutes, may be used as well as fresh objects. All the leaves are separated from the stem, proceeding from the base towards the summit, under the simple microscope, by means of a scalpel. The leaves are placed in their order of succession (their back upward) on slides, in a very small quantity of water (just enough to prevent desiccation). They are then covered, the underside of each cover-glass being moistened with diluted glycerine. If a leaf is brought at once in (even diluted) glycerine, it may curl up before it is possible to place the cover-glass over it.

§ 25. LENGTH OF THE LEAF.—At the base of a leaf separated from the stem one finds easily a more or less irregular curved line *c*, corresponding to the upper limit of the surface of insertion of the leaf. I take as inferior limit of the leaf the point *i*, which is in the centre of the surface limited by the curve *c* and the *transversal* straight line *bb*, the latter being the span of the arch *c*.

FIG. 5.—Lower part of a leaf separated from the stem. See text. *n*, nerve.

Following the nerve, I measure under the microscope the length of the leaf from the extreme summit to *i*. As it is impossible to use a high power according to the dimensions of the object (I used obj. 3 Leitz), and as the position of *i* is not strictly determinable, a positive or negative error of 30 μ (0·03 mm.) is possible.

§ 26. BREADTH OF THE LEAF. PLACE OF THE GREATEST BREADTH.—In almost all the leaves the *place of the greatest breadth* is easily found, the forms represented in fig. 4, *1* and *4* (page 33), being the commonest. In some leaves the greatest breadth extends over a certain length, the margins being parallel (fig. 4, *2*, *3*) : here we agree to take the upper limit of the parallel portion (indicated by B in fig. 4, *2*, *3*) as the place of the greatest breadth. Among the lowest leaves a form similar to fig. 4, *5*, sometimes

occurs: here the base is the broadest part of the leaf. I have considered the breadth of such leaves (which are rare) as unmeasurable.

Sometimes the differentiated border of the leaf is recurved (this happens often in *M. hornum*). Here I measure first the visible breadth *b* (without taking the recurved parts into account); then the recurved parts are measured separately and their breadth is added to *b*.

I estimate the possible + or − error in the measurement of the breadth at 20 μ (0·02 mm.).

§ 27. Breadth at the base.—This property is measured in the direction of a transverse line passing through the point *i* mentioned in § 25 (see fig. 5, p. 34). If the margin is recurved, I use the method described in § 26. As the margins at the base of the leaf are often oblique, a small error in the estimation of the position of *i* may bring about a sensible error in the measurement of the character under consideration. Therefore the possible positive or negative error is proportionally great: I estimate it at 30 μ (0·03 mm.).

§ 28. Number of cells at the place of the greatest breadth.—The place of the greatest breadth being determined (see § 26), I count the cells in the transversal direction, separately in the right and the left half of the leaf. I exclude:—1°, the nerve; 2°, the elongated cells of the differentiated border, except the interior one which is taken into account *. In each half of the leaf I count the cells four times (proceeding twice from the nerve to the margin and twice in the reverse sense) and take the *mean* value of the four figures. Ordinarily these figures differ from each other by one or two units. If the differences are greater †, I go on, counting two or four times more. The sum of the mean values of the two halves is the figure of the leaf.

I estimate the possible positive or negative error at two cells. This estimation is rather too high when the cells are not very numerous (see for instance, the minimal values of *serratum* and *orthorrhynchum* in Table XXIX.).

§ 29. Breadth of the cells at the place of the greatest breadth.—As the form and the *size* of the cells are very variable, even in one leaf, it is practically impossible to obtain useful information about their dimensions by measuring them separately. I have tried to surmount this difficulty by determining the *mean* dimension of the cells in the transverse direction (in other words, their average *breadth*) at the place of the greatest breadth of the leaf.

* If the differentiated border consists of one cell (a single row of cells) this is excluded.

† If the figures are, for instance, 22, −23, −25, −26 (a rather unsatisfactory result).

Having subtracted the breadth of the nerve and the breadth of the two differentiated borders (see § 31) from the total breadth of the leaf, I divide the rest by the number of cells (see § 28) : the quotient is the mean breadth of the cells.

It is very difficult to measure exactly the breadth of the nerve, its lateral limits being rather indistinct. The error, being divided by the number of cells, can be neglected.

I estimate the possible positive or negative error in the value of the mean breadth at 0·5 μ. If the number of cells is small (for instance, 25) the error may reach 1 μ (maximum) *.

The method here described gives very regular results, and is applicable (with the necessary changes) to the measurement of cells, fibres, etc., in numerous objects.

§ 30. NUMBER OF CELLS OF THE BORDER AT THE PLACE OF THE GREATEST BREADTH.—In the 10 species of *Mnium* which I have studied (and in many other Mosses) we find along the margin of the leaves one or several rows of cells which constitute the so-called *border*. The border-cells are differentiated from the neighbouring cells of the leaf by two properties :—1°, they are distinctly elongated, often several times longer than broad, whilst the neighbouring cells are about isodiametrical ; 2°, their cell-walls are thickened.

These two characters, however, seem to be to a certain degree independent of each other, the differentiation being sometimes limited to one of the two. We find, for instance (often in the lowest leaves), border-cells which are distinctly elongated, their walls being hardly or not thickened, and other border-cells which are hardly longer than broad, but the cell-walls of which are thickened. I consider as belonging to the border the cells which are differentiated at least by *one* of both properties. At the inner limit of the border we often find cells (fig. 6, *e*) which are elongated but not thickened. Such cells are taken into account in counting the cells of the border.

As the number of border-cells is variable along the margin, I number the cells three times in each leaf at each side : 1°, at the place of the greatest breadth ; 2°, about 50 to 100 μ (according to the dimension of the leaf) above this place ; 3°, the same below the mentioned place. I take the *highest* of the three figures. The two maxima (right and left border) are

* I want to call attention once more to the usefulness of strict conventions. Instead of saying, for instance, "in *Mnium* sp. the diameter of the cells of the leaves is about 20 μ," I say, "in *Mnium* sp. at the place of the greatest breadth of the longest leaf of a fertile stem the mean breadth of the cells varies between 17 and 24 μ," and I add the possible error. One might say that the disconcerting variation of the character under consideration has been caught and confined between two constants.

added: their sum is the figure of the leaf. Places immediately below a tooth are excluded (fig. 6, *n*).

Example: In fig. 6, I number 3 cells at *a*, 4 cells at *b*, 4 cells at *c* (including *e*), 2 cells at *d*. I take the maximum: 4 cells.

There is no difficulty if the border contains one *layer* of cells (fig. 6). If the border-cells are placed in two (or more?) superposed layers, the cells are numbered as they are seen in the optical section: here an error of one cell is possible, and this may occur in the same sense at both sides of the leaf.

I estimate the possible positive or negative error of the figure of the leaf at 2 cells (1 cell if the cells are not numerous) *.

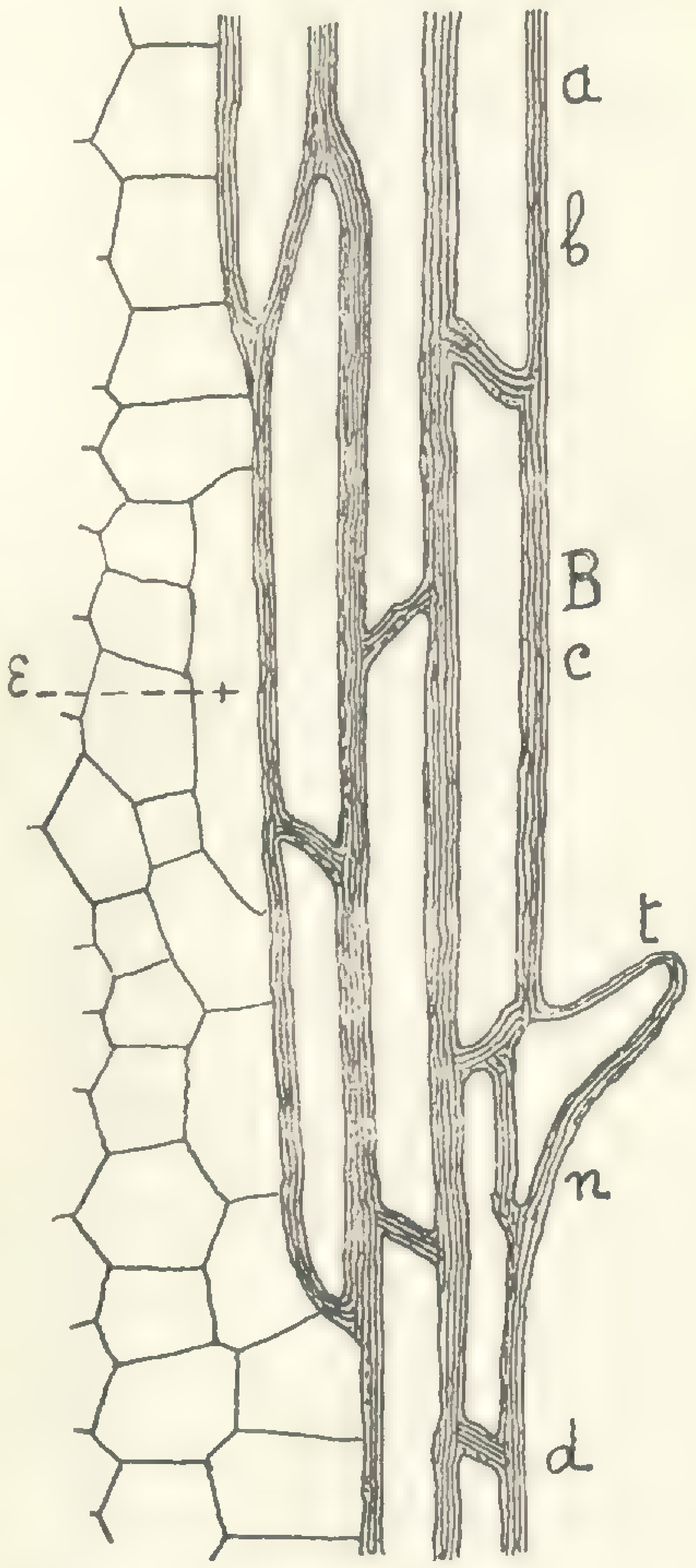

FIG. 6.—Border of a leaf—B, place of the greatest breadth of the leaf. *t*, tooth; *a, b, c, d, e, n*, see § 30.

§ 31. BREADTH OF THE BORDER.—This character also is very variable along the margin. I measure the breadth at three places (same method as for the number of cells, § 30) and take the mean value of the three measurements. The sum of the two mean values (right and left border of the leaf) is the figure of the leaf. I always exclude the interior border-cell, but I include the exterior wall of this cell in the measurement.—*Example* (fig. 6): Measuring the breadth of the border at *a*, I take the two exterior cells, including the wall between the 2nd and the 3rd cell; measuring at B I take three cells, excluding *e* and including the exterior wall of *e*; measuring at *d* I take the exterior cell and the interior wall of this. I calculate the mean value of the measurements *a*, *b*, *c*, and add this to the mean value of the other side of the leaf. I have used obj. 6 Leitz.

I estimate the possible positive or negative error of the figure of a leaf at 5 μ.

* If the border is recurved, it is, of course, impossible to count the border-cells without making sections

§ 32. Number of marginal teeth.—No explanation is needed if all the teeth are simple. If certain teeth are in groups of 2 (even of 3) each group is brought into account as 1. Teeth which are situated below the base of the leaf (see *i* in fig. 5, page 34) are excluded *.

It is sometimes difficult to say whether a given marginal cell ought to be considered as a tooth or not. I consider as a tooth each marginal cell, the distal extremity of which projects beyond the margin by at least one-half of its breadth (see fig. 7).

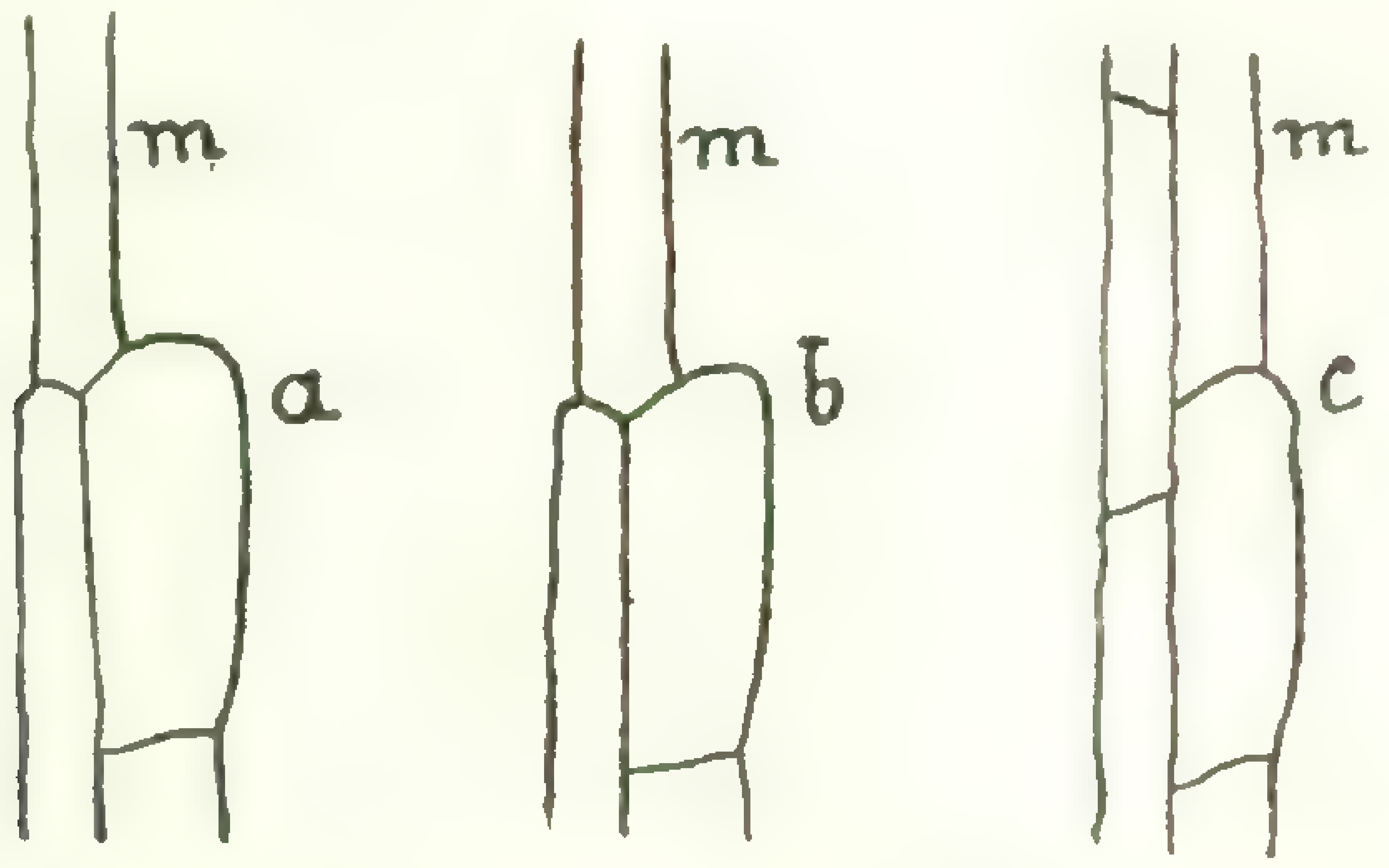

Fig. 7.—Rudimentary teeth. *m*, margin ; *a* and *b* are considered as teeth ; *c* is not taken into account as a tooth.

The figure of a leaf is the *total* number of teeth at the right and the left margin.

I estimate the possible positive or negative error at 1 tooth, if all the teeth are simple. If double or triple teeth exist, the error may reach 3.

§ 33. Number of double (or triple) marginal teeth.—In several species double or even triple teeth exist. These are counted separately. Each group (of 2 or 3 teeth) is taken into account as 1 unit. Figure of the leaf noted as in § 32. Possible positive or negative error, 2.

§ 34. Teeth on the nerve at the back of the leaf.—Careful observation is needed for the counting of these teeth. A group of 2 teeth (situated at the same level—this rarely occurs) is brought into account as 1 unit. Error : the observed number may be too small by 1 unit ; a positive error is almost impossible.

§ 35. Length of the midrib (*reaching the summit or not*).—The length of the nerve is very variable. A measurement of this length is difficult, because

* Such teeth occur in certain decurrent leaves ; for instance, in some leaves of *Mnium undulatum*.

it is often practically impossible to determine the distal limit of the nerve. Therefore I admit three degrees: 1°, the midrib is short and does not reach the summit (fig. 8, *1*); 2°, there is a trace of relation between the extremity of the nerve and the summit (fig. 8, *2*); 3°, the nerve undoubtedly reaches the summit (fig. 8, *3*).

There is no hesitation possible about 1° and 3°. In the 2nd form (intermediate between 1° and 3°) it is sometimes difficult to come to a decision. I bring under 1° (nerve ceasing below the summit; abbreviation −) a leaf in which there is at least one ordinary (isodiametric) cell above the extremity of the nerve (in fig. 8, *1*, there are two such cells).

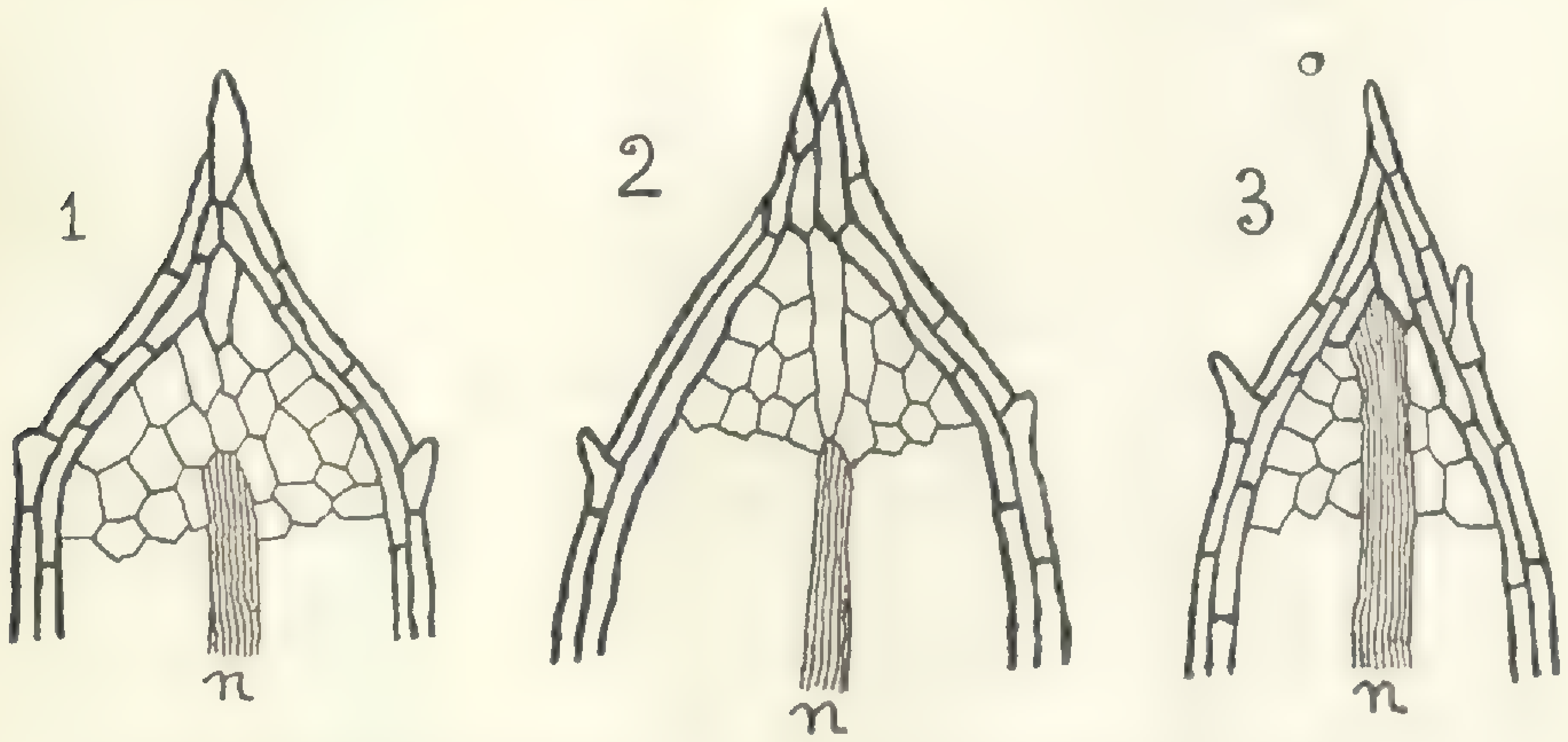

FIG. 8.—Relation between the nerve and the summit of the leaf. *n*, nerve. See text.

About the summit of the leaf the two differentiated borders meet each other, and we find a greater or smaller number of differentiated cells. If the nerve reaches those cells, I bring the leaf under 3° (abbreviation +. Fig. 8, *3*: the nerve often reaches further than in this figure). If the extremity of the nerve is connected with those differentiated cells by one or more distinctly elongated cells, which constitute a sort of bridge among the ordinary isodiametric cells, I bring the leaf under 2° (fig. 8, *2*. Trace of relation; abbreviation ±).

In some cases the decision is rather arbitrary, because the structure near the summit is sometimes indistinct.

§ 36. TOOTH AT THE SUMMIT OF THE LEAF.—No explanation is needed about this character. (Tooth existing, abbreviation + ; tooth not existing, abbreviation −.)

§ 37. NUMBER OF FRUITS.—See the explanation in Table XXXVIII.

PART IV.

Descriptive Tables of Ten Species of the Genus *Mnium*.

§ 38.—In the present part I give the quantitative description of ten British species of the genus *Mnium* *. For two species (*orthorrhynchum*, *spinosum*) which are rarely found in fruit in these Islands, it has been impossible to obtain fertile British specimens ; therefore I examined specimens from the continent, which were kindly given to me by Mr. H. N. Dixon, F.L.S.

The description of each species includes two Tables, viz. :

1°. A Table A, in which I give the *minimum and maximum values of twelve characters of the leaves in the 10th interval* (see § 6 ; § 16, Table XIII. A) *of the fertile stem*, and of two more characters (total number of leaves of the fertile stem and number of fruits). The limits are obtained by the measurement of specimens from as many localities as possible.

Many of the given limits are merely approximate and are very likely to be corrected by further measurements. I hope, however, that corrections will be rather unimportant, except perhaps for three rare species (*affine*, *orthorrhynchum, spinosum*), material of which could not be obtained in sufficient quantity. As they are, the Tables may give an adequate idea of the method.

2°. A Table B, in which I give the gradation curves of the twelve characters of the leaves. For each species the figures in the ten intervals were obtained from specimens of one patch, the curves being *mean interval curves* (see § 7). Therefore the figures have not the significance of *exact* specific figures. Gradation is, indeed, *in a certain degree*, variable from one patch to another. A complete study of this variation would go beyond the limits of this paper. As was remarked in § 8, the relative values of the ordinates of a gradation curve are more important than the absolute values. I prefer, however, to give the absolute values, by means of which the relative values (percentage curves) may be easily calculated (§ 8)—whilst it is impossible to calculate the absolute values by means of percentage curves.

On the definition and the measurement of the characters, see Part III.

Abbreviations : 1°. *Length of the midrib* (see § 35) :

(*a*) Midrib short (ceasing below the summit of the leaf) : —.
(*b*) Nerve longer (a trace of connection between nerve and summit) : $\pm$.
(*c*) Nerve as long as possible (reaching the summit of the leaf) : +.

2°. *Tooth at the summit of the leaf* :

(*a*) Tooth present : +.
(*b*) Tooth absent : —.

* The same method is applicable to other Acrocarpic Mosses.

Table XV.

Description of *Mnium affine*, Bland.

A.—Specific limits of variation.

[Cheshire, 3 stems; e Vogeso superiore, 2 stems.] As the number of specimens is so small, the figures in this Table are merely given for comparison with further measurements. According to Messrs. H. N. Dixon and H. G. Jameson ('British Mosses,' 2nd ed. p. 379), this species varies very greatly. There were no noticeable differences between the specimens from the two mentioned localities.

1. Length of the leaves: 5·44–8·34 mm.
2. Breadth of the leaves: 2·20–4·08 mm.
3. „ „ „ at their base: 0·76–1·16 mm.
4. „ „ cells: 30–43 μ.
5. Number of cells: 56–93.
6. Breadth of the border: 47–92 μ.
7. Number of cells of the border: 5–10.
8. „ marginal teeth: 42–106.
9. „ double marginal teeth: 0.
10. „ teeth on the nerve at the back of the leaves: 0.
11. Length of the nerve: ? (indistinct).
12. Tooth at the summit of the leaves: always existing.
13. Number of leaves: 24–29.
14. „ fruits: 1–4.

B.—Gradation of the characters.

[One patch: Tatton Park, Cheshire, 3 stems.]
Mean interval curves.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	2·02	3·20	3·83	3·86	4·14	3·87	4·47	4·44	5·51	6·38
Breadth leaves (mm.)	1·67	2·61	2·90	2·58	2·64	2·45	2·61	2·58	3·03	2·93
„ base (mm.)	1·04	1·12	1·24	1·16	1·10	1·13	1·06	0·92	0·86	0·89
„ cells (μ)	34	37	35	33	32	31	32	31	35	38
Number cells	53	67	79	74	76	75	75	77	81	72
Breadth border (μ)	69	68	71	68	76	73	77	78	72	67
Cells border	9	9	9	9	9	8·5	8·6	8·5	7·2	7·1
Marginal teeth	5	33	56	58	61	65	68	?	73	62
Double marginal teeth	0	0	0	0	0	0	0	0	0	0
Teeth nerve	0	0	0	0	0	0	0	0	0	0
Length nerve	?	—	—	—	—	—	—	—	—	—
Tooth summit	+	+	+	+	+	+	+	+	+	+

TABLE XVI.

Description of *Mnium cuspidatum*, Hedw.

A.—Specific limits of variation.

[Great Britain: Borrowdale, Harleyford (Bucks), Windermere.—
Europe: Helsingfors.—Canada: Ottawa.]

1. Length of the leaves: 3·73–7·44 mm.
2. Breadth of the leaves: 1·13–3·26 mm.
3. „ „ „ at their base: 0·62–1·26 mm.
4. „ „ cells: 17–22 μ.
5. Number of cells: 56–146.
6. Breadth of the border: 35–89 μ.
7. Number of cells of the border: 5–9.
8. „ marginal teeth: 18–77.
9. „ double marginal teeth: 0.
10. „ teeth on the nerve at the back of the leaves: 0.
11. Length of the nerve: the nerve always reaches the summit of the leaf.
12. Tooth at the summit of the leaves: always existing.
13. Number of leaves: 11–28.
14. „ fruits: 1–2.

B.—Gradation of the characters.

[One patch: Borrowdale, 10 stems.]
Mean interval curves.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	1·31	1·85	2·27	2·66	2·92	3·20	3·61	3·86	4·21	4·41
Breadth leaves (mm.)	1·08	1·44	1·65	1·79	1·80	1·85	1·91	1·88	1·80	1·66
„ base (mm.)	0·81	0·96	1·00	1·01	1·00	0·96	0·95	0·88	0·80	0·76
„ cells (μ)	17	18	19	20	20	20	20	20	19	19
Number cells	58	72	81	81	85	86	88	88	86	80
Breadth border (μ)	67	72	76	79	79	80	73	70	62	53
Cells border	9·4	10·0	10·3	10·3	10·1	9·8	9·5	8·9	8·4	7·7
Marginal teeth	15	25	32	36	36	41	41	41	40	38
Double marginal teeth	0	0	0	0	0	0	0	0	0	0
Teeth nerve	0	0	0	0	0	0	0	0	0	0
Length nerve	−	±−	+−	+−	+−	+±	+	+	+	+
Tooth summit	+	+	+	+	+	+	+	+	+	+

Table XVII.

Description of *Mnium hornum*, Linn.

A.—Specific limits of variation.

[6 localities in Great Britain.]

1. Length of the leaves: 5·17–8·06 mm.
2. Breadth of the leaves: 0·64–1·46 mm.
3. „ „ „ at their base: 0·55–0·98 mm.
4. „ „ cells: 14–20 μ.
5. Number of cells: 34–73.
6. Breadth of the border of the leaves (often recurved): ?.
7. Number of cells of the border (often recurved, see § 30): ?.
8. „ marginal teeth: 46–84.
9. „ double (and triple) marginal teeth: 34–61.
10. Teeth on the nerve at the back of the leaf: 4–9.
11. Length of the nerve: nerve reaching the summit (+), ceasing below the summit (−), or intermediate form (±).
12. Tooth at the summit of the leaf: always existing.
13. Number of leaves: 46–64 (perhaps more, as many as 80?—See § 23).
14. „ fruits: always 1.

B.—Gradation of the characters.

[One patch: Dungeon Ghyll, Lake District, 8 stems.]

Mean interval curves.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	2·00	2·51	2·90	3·28	3·75	4·23	4·65	5·24	6·01	6·79
Breadth leaves (mm.)	0·53	0·63	0·74	0·91	1·11	1·26	1·32	1·41	1·43	1·18
„ base (mm.)	0·50	0·57	0·61	0·68	0·74	0·76	0·77	0·81	0·85	0·84
„ cells (μ)	12	13	14	15	16	17	17	17	18	18
Number cells	35	39	44	52	60	66	69	72	72	58
Breadth border	?	..	..	..	..	..	..	..	..	..
Cells border	?	..	..	..	..	..	..	..	..	..
Marginal teeth	1·5	3	10	23	35	42	49	55	59	67
Double marginal teeth	0·1	1·3	4	13	23	30	36	41	43	48
Teeth nerve	0	0	0	0·7	1·9	3·4	4·9	6·4	7·6	9
Length nerve *	−	+ −	−	−	−	± −	+ −	+ −	+ −	+ −
Tooth summit	+	+	+	+	+	+	+	+	+	+

* In the intervals 1–8 all the leaves were −, except: 1°, in each of the intervals 2, 7, 8, one leaf +; 2°, in interval 6, one leaf ±.

Table XVIII.

Description of *Mnium orthorrhynchum*, Bruch, Schimp. & Guemb.

A.—Specific limits of variation.

[Boulder, Engstligen Falls, Adelboden (Switzerland).—H. N. Dixon dedit.]

1. Length of the leaves: 3·00–5·41 mm.
2. Breadth of the leaves: 0·30–1·03 mm.
3. " " " at their base: 0·31–0·56 mm.
4. " " cells: 12–15 μ.
5. Number of cells: 21–62.
6. Breadth of the border: 23–45 μ.
7. Number of cells of the border: 3–7.
8. " marginal teeth: 22–38.
9. " double marginal teeth: 12–31.
10. " teeth on the nerve at the back of the leaves: 0–11.
11. Length of the nerve: in 48 leaves I found the nerve reaching the summit; in 2 leaves merely a trace of connection between nerve and summit.
12. Tooth at the summit of the leaves: always existing.
13. Number of leaves: 25–61.
14. " fruits: always 1.

B.—Gradation of the characters.

[One patch: Adelboden, 8 stems.]

Mean interval curves.

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	0·76	0·99	1·23	1·41	1·59	2·06	2·34	2·91	3·19	3·96
Breadth leaves (mm.)	0·36	0·42	0·50	0·56	0·65	0·84	0·93	0·93	0·83	0·64
" base (mm.)	0·31	0·34	0·36	0·38	0·41	0·48	0·49	0·47	0·42	0·40
" cells (μ)	11	11	12	12	13	14	14	14	14	13
Number cells	28	32	37	40	46	53	60	60	52	42
Breadth border (μ)	24	27	28	28	28	31	33	34	36	33
Cells border	5	6	6	6	6	6	6	6	6	5
Marginal teeth	1	2	5	7	10	15	21	26	26	29
Double marginal teeth	0	0·4	1·3	3	5	10	13	18	19	20
Teeth nerve	0	0	0	0	0·2	0·6	1	2	3	4
Length nerve	±−	±−	+−	+−	±−	+±	+−	+−	+±	+
Tooth summit	+	+	+	+	+	+	+	+	+	+

Table XIX.

Description of *Mnium punctatum*, Linn.

A.—Specific limits of variation.

[Seven localities in Great Britain.—Island Gräsen (Sweden).]

1. Length of the leaves: 4·35–9·21 mm.
2. Breadth of the leaves: 2·71–6·48 mm.
3. „ „ „ at their base: 0·44–0·82 mm.
4. „ „ cells: 36–65 μ.
5. Number of cells: 61–111.
6. Breadth of the border: 82–195 μ.
7. Number of cells of the border: 8–11.
8. „ marginal teeth: 0.
9. „ double marginal teeth: 0.
10. „ teeth on the nerve at the back of the leaves: 0.
11. Length of the nerve: the nerve reaches the summit in the great majority of the cases. It always reaches the summit in the second leaf above the longest one and higher upwards.
12. Tooth at the summit of the leaves: a tooth is almost always existing. It always exists in the second leaf above the longest one and higher upwards.
13. Number of leaves: 7–19.
14. „ fruits: 1–2.

B.—Gradation of the characters.

[One patch: Llanberis to Bangor, 11 stems.]

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	2·10	2·56	3·53	3·63	4·59	4·98	5·73	6·17	6·99	7·19
Breadth leaves (mm.)	1·68	1·98	2·93	3·17	3·35	3·59	3·77	3·64	4·08	4·02
„ base (mm.)	0·58	0·63	0·64	0·64	0·64	0·62	0·64	0·62	0·60	0·57
„ cells (μ)	39	40	50	46	46	47	45	42	45	45
Number cells	38	38	52	65	70	71	80	82	88	85
Breadth border (μ)	88	90	111	117	124	120	129	118	128	133
Cells border	6·2	7·1	8·5	8·8	9·3	9·0	9·5	10	9·5	9·5
Marginal teeth	0	0	0	0	0	0	0	0	0	0
Double marginal teeth	0	0	0	0	0	0	0	0	0	0
Teeth nerve	0	0	0	0	0	0	0	0	0	0
Length nerve	–	–	–	–	±–	+–	+–	+–	+–	+–
Tooth summit	+–	+–	+–	+–	+	+–	+–	+–	+–	+–

Table XX.

Description of *Mnium rostratum*, Schrad.

A.—Specific limits of variation.

[Great Britain : Alston to High Force, Dunkeld, Llangadock, Whaley Bridge.]

1. Length of the leaves: 4·35–8·32 mm.
2. Breadth of the leaves: 1·80–3·19 mm.
3. ,, ,, ,, at their base: 0·73–1·24 mm.
4. ,, ,, cells: 23–34 μ.
5. Number of cells: 62–97.
6. Breadth of the border: 69–125 μ.
7. Number of cells of the border: 6–12.
8. ,, marginal teeth: ? (teeth rather numerous, but partly obsolete).
9. ,, double marginal teeth: 0.
10. ,, teeth on the nerve at the back of the leaves: 0.
11. Length of the nerve: nerve always reaching the summit (one leaf doubtful).
12. Tooth at the summit of the leaves: always existing.
13. Number of leaves: 12–21.
14. ,, fruits: 1–4.

B.—Gradation of the characters.

[One patch : Alston to High Force, 9 stems.]

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	2·23	2·95	3·01	4·07	4·04	4·51	5·46	5·59	6·02	6·47
Breadth leaves (mm.)	1·22	1·80	1·77	2·04	2·13	2·26	2·56	2·40	2·36	2·47
,, base (mm.)	0·69	0·75	0·73	0·78	0·75	0·75	0·82	0·84	0·96	1·07
,, cells (μ)	26	29	28	29	31	31	32	30	30	29
Number cells	43	55	58	58	59	67	73	73	71	77
Breadth border (μ)	70	89	88	93	88	85	90	90	89	90
Cells border	8	9	9	9	8	9	8	9	8	8
Marginal teeth	?	..	..	..	..	..	..	..	..	..
Double marginal teeth	0	0	0	0	0	0	0	0	0	0
Teeth nerve	0	0	0	0	0	0	0	0	0	0
Length nerve	+ −	+ ±	+ ±	+ ±	+ −	+ ±	+ ±	+ ±	+ ±	+
Tooth summit	+	+	+	+	+	+	+	+	+	+

Table XXI.

Description of *Mnium serratum*, Schrad.

A.—Specific limits of variation.

[Great Britain: Ben Lawers, Ingleton, High Force, South Wales, Gilsland Alston, Craven.—Canada.]

1. Length of the leaves: 2·49–4·71 mm.
2. Breadth of the leaves: 0·59–1·31 mm.
3. „ „ „ at their base: 0·38–0·71 mm.
4. „ „ cells: 17–25 μ.
5. Number of cells: 28–57.
6. Breadth of the border: 36–101 μ.
7. Number of cells of the border: 5–9.
8. „ marginal teeth: 11–29.
9. „ double marginal teeth: 6–21.
10. „ teeth on the nerve at the back of the leaves: 0.
11. Length of the nerve: nerve always reaching the summit in Great Britain. (Canada: + or ±.)
12. Tooth at the summit of the leaves: always existing.
13. Number of leaves: 16–36. (Great Britain: 21–36. Canada: 16–24.)
14. „ fruits: 1.

B.—Gradation of the characters.

[One patch: Ben Lawers, 9 stems.—Barker leg., July 1870.]

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	1·44	1·70	1·95	2·15	2·37	2·62	2·79	3·09	3·43	4·03
Breadth leaves (mm.)	0·63	0·78	0·87	1·01	1·09	1·19	1·26	1·29	1·29	1·13
„ base (mm.)	0·47	0·50	0·51	0·53	0·56	0·59	0·59	0·57	0·52	0·52
„ cells (μ)	17	17	18	20	21	22	23	23	23	23
Number cells	37	40	41	44	46	47	50	50	50	43
Breadth border (μ)	54	57	61	66	68	69	70	71	76	78
Cells border	8·5	8	9	9	8·8	8·5	8·1	8·3	7·8	7·9
Marginal teeth	0	0·2	0·5	1·6	5	8·4	12	17	18	16
Double marginal teeth	0	0	0	0	0·8	3·5	6·6	12	12	11
Teeth nerve	0	0	0	0	0	0	0	0	0	0
Length nerve	±−	±−	+−	+−	+−	+±	+±	+−	+	+
Tooth summit	+	+	+	+	+	+	+	+	+	+

Table XXII.

Description of *Mnium spinosum*, Schwaeg.

A.—Specific limits of variation.

[Switzerland: Engstligen Falls, Adelboden; H. N. Dixon dedit.—Styria: in sylvis prope St. Nicolaï, in vallo Solk.—Very rare in the British Islands.]

1. Length of the leaves: 5·01–8·10 mm.
2. Breadth of the leaves: 1·55–2·84 mm.
3. " " " at their base: 0·68–1·06 mm.
4. " " cells: 21–31 μ.
5. Number of cells: 65–96.
6. Breadth of the border: 62–92 μ.
7. Number of cells of the border: 10–13.
8. " marginal teeth: 43–72.
9. " double marginal teeth: 33–47.
10. " teeth on the nerve at the back of the leaves: 2–12.
11. Length of the nerve: nerve always reaching the summit.
12. Tooth at the summit of the leaves: always existing.
13. Number of leaves: 24–33.
14. " fruits: 2–6.

B.—Gradation of the characters.

[One patch: Adelboden, 8 stems.]

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	1·53	2·80	4·55	5·37	5·91	6·16	6·33	6·69	6·93	7·26
Breadth leaves (mm.)	0·75	1·41	2·42	2·80	2·86	2·81	2·76	2·74	2·66	2·52
" base (mm.)	0·81	0·95	1·14	1·10	1·10	1·02	0·95	0·92	0 89	0·90
" cells (μ)	15	22	27	29	29	29	29	29	28	28
Number cells	40	59	84	91	91	90	88	88	87	82
Breadth border (μ)	65?	73	75	76	73	73	75	73	74	76
Cells border	10?	11	11	11	10	11	11	11	11	11
Marginal teeth	2·7	18	35	44	47	52	55	57	63	63
Double marginal teeth	0	2	12	24	25	30	34	38	40	42
Teeth nerve	0	0	0·1	1	1·6	2·8	3·1	4·9	4·8	7·5
Length nerve	+−	+−	+	+	+	+	+	+	+	+
Tooth summit	+	+	+	+	+	+	+	+	+	+

Table XXIII.

Description of *Mnium subglobosum*, Bruch, Schimp. & Guemb.

A.—Specific limits of variation.

[Great Britain: Benson Knot (Kendal), Whaley Bridge, Hathersage, Derbyshire.]

1. Length of the leaves: 3·62 7·33 mm.
2. Breadth of the leaves: 2·95–5·50 mm.
3. „ „ „ at their base: 0·58–0·98 mm.
4. „ „ cells: 38 54 μ.
5. Number of cells: 71–106.
6. Breadth of the border: 53–85 μ.
7. Number of cells of the border: 4–6.
8. „ marginal teeth: 0.
9. „ double marginal teeth: 0.
10. „ teeth on the nerve at the back of the leaves: 0.
11. Length of the nerve: nerve never reaching the summit. (Very rarely a trace of connection between nerve and summit in the third leaf above the longest one. Nerve sometimes reaching the summit in the phyllomes of the perianth.)
12. Tooth at the summit of the leaves: never existing. (A trace of a tooth in the above-mentioned exceptional leaf. The phyllomes of the perianth sometimes with a tooth.)
13. Number of leaves: 7–14.
14. „ fruits: 1–2.

B.—Gradation of the characters.

[One patch: 11 stems with about 70 leaves in good condition; many leaves were spoiled and not measurable, especially in the intervals 1–5. Benson Knot, Kendal.]

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	1·34	2·04	2·58	3·08	2·96	3·65	4·13	4·77	5·00	5·79
Breadth leaves (mm.)	1·07	1·59	1·99	2·56	2·31	2·86	3·23	3·86	3·70	4·41
„ base (mm.)	0·56	0·65	0·73	0·73	0·69	0·74	0·68	0·71	0·77	0·78
„ cells (μ)	31	36	38	42	39	41	41	45	44	47
Number cells	29	41	52	55	56	66	72	78	75	91
Breadth border (μ)	59	66	65	68	65	65	62	61	63	65
Cells border	4	4	4	5	5	5	5	5	5	5
Marginal teeth	0	0	0	0	0	0	0	0	0	0
Double marginal teeth	0	0	0	0	0	0	0	0	0	0
Teeth nerve	0	0	0	0	0	0	0	0	0	0
Length nerve	—	—	—	—	—	—	—	—	—	—
Tooth summit	—	—	—	—	—	—	—	—	—	—

Table XXIV.

Description of *Mnium undulatum*, Linn.

A.—Specific limits of variation.

[Great Britain: Manchester; Bolton Abbey.]

1. Length of the leaves: 6·93–15·58 mm.
2. Breadth of the leaves: 1·71–2·35 mm.
3. " " " at their base: 1·02–1·47 mm.
4. " " cells: 17–23 μ.
5. Number of cells: 76–103.
6. Breadth of the border: 40–97 μ.
7. Number of cells of the border: 6–11.
8. " marginal teeth: 84–134.
9. " double marginal teeth: 0.
10. " teeth on the nerve at the back of the leaves: 0.
11. Length of the nerve: nerve always reaching the summit.
12. Tooth at the summit of the leaves: always existing.
13. Number of leaves: 33–58 (or more?).
14. " fruits: 2–8 (the fertile stem is sometimes ramified, the branches being fertile; the fruits of such lateral branches are not taken into account).

B.—Gradation of the characters.

[Two patches: Manchester, 7 stems with about 210 leaves, the leaves above the longest leaf being excluded.]

Intervals:	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Length leaves (mm.)	1·59	2·35	3·72	5·40	6·27	6·78	8·23	8·54	8·94	10·15
Breadth leaves (mm.)	1·55	1·65	1·89	2·25	2·20	2·12	2·22	2·18	2·12	2·09
" base (mm.)	1·32	1·39	1·62	1·82	1·80	1·70	1·69	1·54	1·43	1·26
" cells (μ)	22	22	22	22	21	21	21	21	21	21
Number cells	63	71	76	91	92	89	91	90	89	89
Breadth border (μ)	81	82	84	83	87	86	88	88	88	78
Cells border	10	12	12	11	12	11	11	11	11	9
Marginal teeth	29	48	66	87	96	102	109	115	116	119
Double marginal teeth	0	0	0	0	0	0	0	0	0	0
Teeth nerve	0	0	0	0	0	0	0	0	0	0
Length nerve	±−	+−	+±	+±	+±	+±	+±	+±	+	+
Tooth summit	+	+	+	+	+	+	+	+	+	+

PART V.

Tables of Identification.

§ 39.—In the present part I give tables of identification for the ten species of *Mnium* which are described in Part IV. The British Flora includes four species (*lycopodioides*, Schwaeg., *riparium*, Mitt., *stellare*, Reich., *cinclidioides*, Blytt) which are not mentioned in the tables; these are rare (or very rarely or never found in fruit) in the British Islands. In each table the minimum and maximum limits of the character under consideration are given separately.

In the descriptive tables (Part IV.) the figures are given as they were observed. As the limit-values are hitherto merely approximate, they are MODIFIED in the tables of identification in the following way:—

1°. The minimum figures are diminished by about 5 per cent. of the observed value, and for three species (*affine*, *orthorrhynchum*, *spinosum*, see § 38, p. 40) by about 10 per cent.

2°. The maximum figures are *augmented* by about 5 per cent. of the observed value, and for the three mentioned species by about 10 per cent.

By these modifications (which are arbitrary) the limits between which variation may occur are widened by about one-tenth (or one-fifth) in order to diminish the possibility of mistakes in identifying a given specimen.

Despite this, it is advisable to be prudent in the use of the tables and to allow a wide range of error, as we have done in § 17 (see p. 26), in which the THREE METHODS of using the tables are illustrated by examples.

ABBREVIATIONS: see § 38, p. 40.

Table XXV. (see § 25).

Length of the leaves in the 10th interval (mm.).

Minimum.		Maximum.	
serratum	2·36	*serratum*	4·95
orthorrhynchum	2·70	*orthorrhynchum*	5·94
subglobosum	3·44	*subglobosum*	7·70
cuspidatum	3·55	*cuspidatum*	7·81
punctatum	4·12	*hornum*	8·46
rostratum	4·12	*rostratum*	8·73
spinosum	4·50	*spinosum*	8·91
hornum	4·90	*affine*	9·17
affine	4·90	*punctatum*	9·67
undulatum	6·60	*undulatum*	16·36

TABLE XXVI. (see § 26).

Breadth of the leaves in the 10th interval (mm.).

Minimum.		Maximum.	
orthorrhynchum	0·27	*orthorrhynchum*	1·13
serratum	0·56	*serratum*	1·38
hornum	0·61	*hornum*	1·54
cuspidatum	1·07	*undulatum*	2·47
spinosum	1·40	*spinosum*	3·12
undulatum	1·62	*rostratum*	3·35
rostratum	1·71	*cuspidatum*	3·43
affine	1·98	*affine*	4·49
punctatum	2·71	*subglobosum*	5·78
subglobosum	2·80	*punctatum*	6·81

TABLE XXVII. (see § 27).

Breadth of the leaves at their base in the 10th interval (mm.).

Minimum.		Maximum.	
orthorrhynchum	0·28	*orthorrhynchum*	0·62
serratum	0·36	*serratum*	0·75
punctatum	0·42	*punctatum*	0·86
hornum	0·52	*hornum*	1·03
subglobosum	0·55	*subglobosum*	1·03
cuspidatum	0·59	*spinosum*	1·17
spinosum	0·61	*affine*	1·28
affine	0·68	*rostratum*	1·30
rostratum	0·69	*cuspidatum*	1·32
undulatum	0·96	*undulatum*	1·55

TABLE XXVIII. (see § 29).

Breadth of the cells at the place of the greatest breadth of the leaves in the 10th interval (μ).

Minimum.		Maximum.	
orthorrhynchum	11	*orthorrhynchum*	17
hornum	13	*hornum*	21
cuspidatum	16	*cuspidatum*	23
serratum	16	*undulatum*	24
undulatum	16	*serratum*	26
spinosum	18	*rostratum*	36
rostratum	22	*spinosum*	37
affine	27	*affine*	47
punctatum	34	*subglobosum*	57
subglobosum	36	*punctatum*	68

Table XXIX. (see § 28).

Number of cells at the place of the greatest breadth of the leaves in the 10th interval.

Minimum.		Maximum.	
orthorrhynchum	19	*serratum*	60
serratum	27	*orthorrhynchum*	68
hornum	32	*hornum*	77
affine	50	*affine*	102
cuspidatum	53	*rostratum*	102
punctatum	58	*spinosum*	106
rostratum	59	*undulatum*	108
spinosum	59	*subglobosum*	112
subglobosum	67	*punctatum*	117
undulatum	72	*cuspidatum*	154

Table XXX. (see § 31).

Breadth of the border at the place of the greatest breadth of the leaves in the 10th interval (μ).

Minimum.		Maximum.	
hornum	?	*orthorrhynchum*	50
orthorrhynchum	21	*subglobosum*	90
cuspidatum	33	*cuspidatum*	94
serratum	34	*affine*	102
undulatum	38	*spinosum*	102
affine	42	*undulatum*	102
subglobosum	50	*serratum*	106
spinosum	56	*rostratum*	132
rostratum	65	*punctatum*	205
punctatum	77	*hornum*	?

Table XXXI. (see § 30).

Number of cells of the border at the place of the greatest breadth of the leaves in the 10th interval.

Minimum.		Maximum.	
hornum	?	*subglobosum*	7
orthorrhynchum	2	*orthorrhynchum*	8
subglobosum	3	*cuspidatum*	10
affine	4	*serratum*	10
cuspidatum	4	*affine*	11
serratum	4	*punctatum*	12
rostratum	5	*undulatum*	12
undulatum	5	*rostratum*	13
punctatum	7	*spinosum*	14
spinosum	9	*hornum*	?

TABLE XXXII. (see § 32).

Number of marginal teeth of the leaves in the 10th interval.

Minimum.		Maximum.	
punctatum	0	*punctatum*	0
subglobosum	0	*subglobosum*	0
rostratum *	n?	*serratum*	31
serratum	10	*orthorrhynchum*	42
cuspidatum	17	*spinosum*	80
orthorrhynchum	20	*cuspidatum*	81
affine	38	*hornum*	89
spinosum	39	*affine*	117
hornum	43	*undulatum*	141
undulatum	80	*rostratum* *	n?

TABLE XXXIII. (see § 33).

Number of double (and triple) marginal teeth of the leaves in the 10th interval.

Minimum.		Maximum.	
affine	0	*affine*	0
cuspidatum	0	*cuspidatum*	0
punctatum	0	*punctatum*	0
rostratum	0	*rostratum*	0
subglobosum	0	*subglobosum*	0
undulatum	0	*undulatum*	0
serratum	5	*serratum*	22
orthorrhynchum	11	*orthorrhynchum*	34
spinosum	30	*spinosum*	51
hornum	32	*hornum*	64

TABLE XXXIV. (see § 34).

Number of teeth on the nerve at the back of the leaves in the 10th interval.

Minimum.		Maximum.	
affine	0	*affine*	0
cuspidatum	0	*cuspidatum*	0
orthorrhynchum	0	*punctatum*	0
punctatum	0	*rostratum*	0
rostratum	0	*serratum*	0
serratum	0	*subglobosum*	0
subglobosum	0	*undulatum*	0
undulatum	0	*orthorrhynchum*	12
spinosum	1	*spinosum*	13
hornum	3	*hornum*	20

* In *Mnium rostratum* marginal teeth always exist, but it was impossible to count them exactly. See Table XX., A.

Table XXXV. (see § 35).

Length of the nerve in the leaves of the 10th interval. (Nerve reaching the summit, +; a trace of connection between nerve and summit, ±; nerve ceasing below the summit, –.)

Minimal length of the nerve.		Maximal length of the nerve.	
affine	?	*subglobosum*	–
rostratum	?	*cuspidatum*	+
hornum	–	*hornum*	+
punctatum	–	*orthorrhynchum*	+
subglobosum	–	*punctatum*	+
orthorrhynchum	±	*rostratum*	+
serratum	±	*serratum*	+
cuspidatum	+	*spinosum*	+
spinosum	+	*undulatum*	+
undulatum	+	*affine*	?

Table XXXVI. (see § 36).

Tooth at the summit of the leaves in the 10th interval.

A tooth at the summit of the leaves in the 10th interval exists always in all the species, except in two of them, viz. :—

1°. *Mn. punctatum.* The tooth exists ordinarily, or there is a trace of a tooth. The absence of a tooth is rather *rare.* The first leaf above the longest one is variable in the same way. In the *second* leaf above the longest one and further upwards I always found a tooth.

2°. *Mn. subglobosum.* *Never* a terminal tooth in the 10th interval, *nor* in the *two* leaves above the longest one. In a few cases a trace of a tooth exists in the third leaf above the longest one. A tooth *may* occur at the summit of the phyllomes of the perianth.

See, with reference to this character, the specific tables of gradation (Tables XV.–XXIV., B).

Table XXXVII. (see § 23).

Number of leaves of the fertile stem.

In this table a rather great possible error is to be admitted. The figures indicate the number of leaves which still remain in a stem which bears a ripe or almost ripe fruit. In such stems the lowest leaves have almost always disappeared. (See § 23.)

Minimum.		Maximum.	
punctatum	6	*subglobosum*	15
subglobosum	6	*punctatum*	20
cuspidatum	10	*rostratum*	22
rostratum	11	*cuspidatum*	30
serratum	15	*affine*	30
spinosum	22	*spinosum*	36
orthorrhynchum	23	*serratum*	38
affine	25	*undulatum*	61
undulatum	31	*orthorrhynchum*	67
hornum	46	*hornum*	67 (or more).

Table XXXVIII. (see § 37).

Number of fruits at the summit of the fertile stem (see § 37).

In several species this property is very variable. The figures in this table are to be considered as a rather incomplete information. Besides the fully-developed fruits, *abortive* fruits (length 2 mm. or longer) which are easily distinguished from *sterile* archegonia are sometimes found; such abortive fruits have always been counted and brought into account. In all the species, stems with one fruit will likely be found. Fruits which sometimes occur at the summit of lateral branches (*Mn undulatum* and perhaps other species) are not taken into account.

Minimum.		Maximum.	
affine	1	*hornum*	1
cuspidatum	1	*orthorrhynchum*	1
hornum	1	*serratum*	1
orthorrhynchum	1	*cuspidatum*	2
punctatum	1	*punctatum*	2
rostratum	1	*subglobosum*	2
serratum	1	*affine*	4
subglobosum	1	*rostratum*	4
spinosum	2	*spinosum*	6
undulatum	2	*undulatum*	8

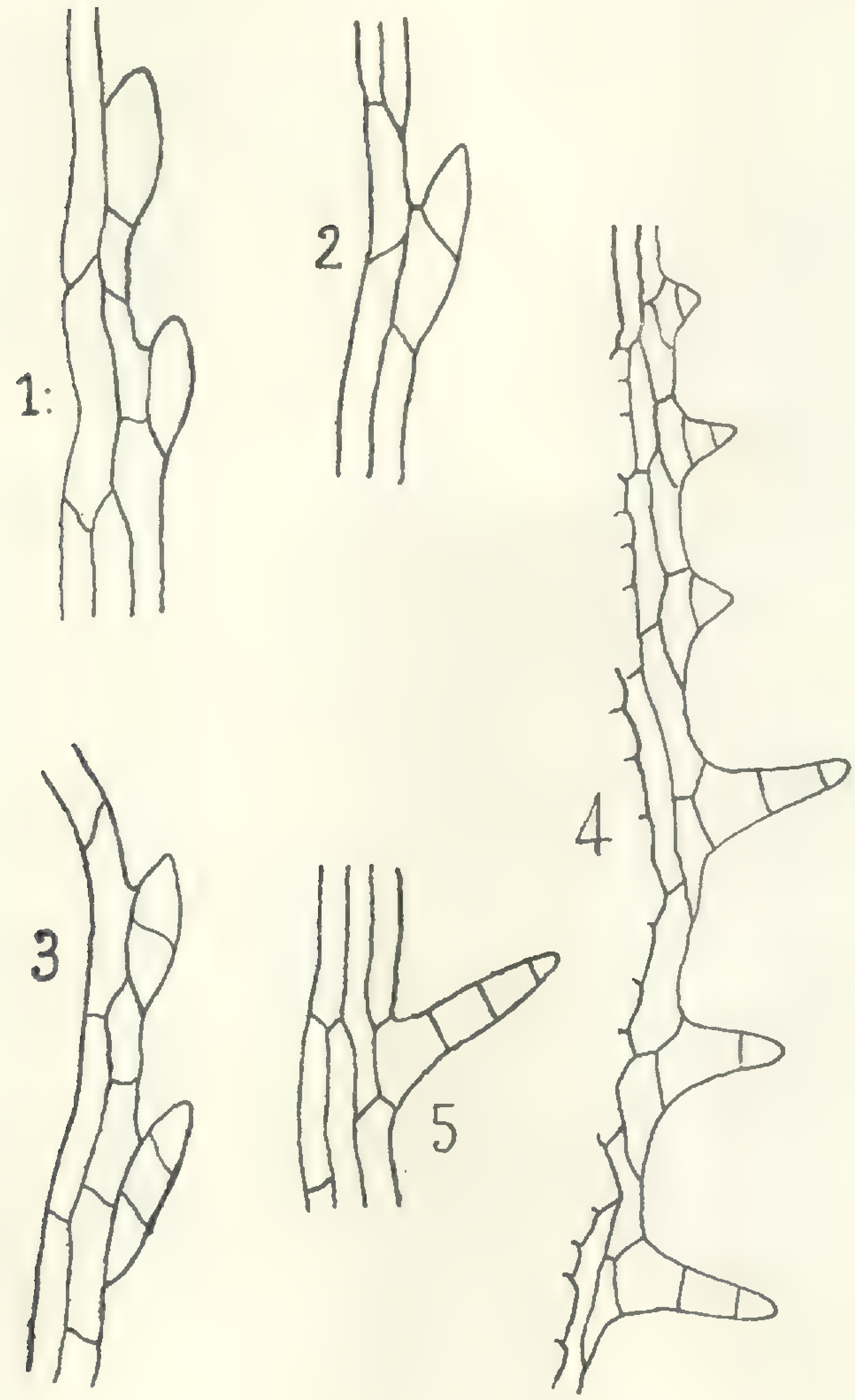

FIG. 9.—Marginal teeth (see p. 58).

1, 2, 3: *Mnium rostratum.*

4, 5: *Mnium affine.*—*4.* Part of the margin of a leaf, with 1-cellular, 2-cellular, and 3-cellular teeth; *5.* A 4-cellular tooth (rare).

Table XXXIX.

Number of cells of the marginal teeth. (With reference to *M. affine* and *rostratum*.)

In order to test the practical value of the method, I have tried to identify several specimens of each species by means of the Tables XXV.–XXXVIII. I always succeeded, except with *some* specimens of *M. affine* and *rostratum*. These species cannot be confounded when the classic characters of the fruit and the inflorescence * are taken into account. But when we limit ourselves to the characters of the leaves, there is frequently some difficulty in the determination.

Using merely the figures of the longest leaf of *one* fertile stem (first method, see § 17), some specimens of both species could be determined. But the figures of other specimens were not *decisive* ; after all the tables had been used, I was still hesitating between *affine* and *rostratum*. Therefore I have recourse to a supplementary character.

In both species, the longest leaves (10th interval) of the fertile stem are adorned with numerous marginal teeth, which are always simple (never in pairs). In *M. rostratum*, about the place of the greatest breadth of the longest leaves, the *salient part* of each tooth always consists of one cell (fig. 9 : *1*, *2*, *3*). In *M. affine*, at the mentioned place, the salient part of the teeth consists of 1, 2, 3, or even 4 cells. Among those teeth, one always finds some teeth the salient part of which consists of *more* than one cell (fig. 9 : *4*, *5*).

All this may be shown in the form of the following table :—

Minimum.		Maximum.	
rostratum	1 cell.	*rostratum*	1 cell.
affine	1 cell.	*affine*	4 cells.

* *M. affine* : lid of the capsule conical, apiculate ; inflorescence dioicous.

M. rostratum : lid of the capsule with a long, straight, or curved rostrate beak ; inflorescence synoicous.

See Dixon and Jameson, 'British Mosses,' second edition, 1904, pp. 379, 381.

The Heterangiums of the British Coal Measures.

By D. H. Scott, M.A., LL.D., F.R.S., F.L.S.

(Plates 1–4.)

[Read 19th April, 1917.]

Heterangium is a genus of Carboniferous plants based on petrified specimens with the anatomical structure preserved; it is now classed among the Pteridosperms. The characters of the genus are briefly as follows:—

Stem monostelic; vascular cylinder a protostele, the primary xylem, interspersed with conjunctive parenchyma, extending to the centre and consisting throughout of elongated tracheides; peripheral strands of stele and leaf-trace bundles mesarch.

Secondary wood and bast formed. Tracheides (apart from the protoxylem-region) with multiseriate bordered pits.

Leaf-trace bundles one or more for each leaf.

Outer cortex consisting of alternating radial bands of sclerenchyma and parenchyma.

Inner cortex, or pericycle, or both, usually with plates of sclereides.

Leaves (when known) large, compound, and of the *Sphenopteris* type.

This definition, while correct so far as it goes, will be found to need some emendation when the results of the present investigation are taken into consideration (see p. 99).

The genus *Heterangium* was founded by Corda in 1845, on some fragments from the "sphaero-siderites" (coal-balls) of Radnitz in Bohemia, probably of Middle Coal-Measure age (Corda, 1845). Corda's specimens showed little more than portions of the wood; somewhat better examples of the species, *H. paradoxum*, have recently been obtained by Kubart from the same material (Kubart, 1911).

In 1873 Williamson described in detail a fossil plant from the Pettycur deposits, near Burntisland, of Lower Carboniferous age; he referred his specimens to Corda's genus, under the name *Heterangium Grievii* (Williamson, 1873). This has now come to be the best-known species of the genus, as it is also the most ancient *. Williamson's reference of his plant to Corda's genus was criticised by Renault (1879, p. 277), but has been confirmed by subsequent writers (Solms-Laubach, 1887; Kubart, 1911), and *H. Grievii* is now for practical purposes the type-species of *Heterangium*, though technically *H. paradoxum*, Corda, claims this position.

Much later, in 1887, Williamson described a species of *Heterangium* from the Halifax Beds (Lower Coal Measures). This was *H. tiliæoides*, a form

* See also Williamson & Scott, 1895.

remarkable for its perfect preservation, especially as regards the phloem (Williamson, 1887 ; Williamson & Scott, 1895).

These two species, *H. Grievii* of Lower and *H. tiliæoides* of Upper Carboniferous age, were the only British species recognised by Williamson in his published works.

In 1890, however, he described some specimens from Dulesgate (Lower Coal Measures) under the name *H. Grievii*, and thus made this species range from the Lower to the Upper Carboniferous (Williamson, 1890). Williamson at first thought that some, at least, of these Dulesgate specimens were a different species, and gave them in MS. the name *H. Lomaxii*, but in his published account all are included under the name *H. Grievii*. The difficulty of identifying plants of such different horizons does not seem to have troubled Williamson at all. In the joint paper by Williamson and the present writer the same nomenclature was unfortunately adopted, though some distinctions between the Dulesgate and Burntisland forms were pointed out (Williamson & Scott, 1895, pp. 750 & 753). At the same time a Dulesgate specimen, differing somewhat from the others, was given the provisional name of *H. cylindricum*, though its claims to specific distinction were regarded as doubtful (*l. c.* p. 765).

In my 'Studies in Fossil Botany' (1st ed. 1900) it was recognised that Williamson's Dulesgate specimens of "*Heterangium Grievii*" probably represented a separate species (*l. c.* p. 345) ; in a second edition (1909, p. 410) Williamson's MS. name, *H. Lomaxii*, was definitely adopted for them. No full or critical account of the Dulesgate Heterangiums has, however, yet been given, and it is one object of the present communication to supply this omission.

The stimulus to undertake a revision of British Coal-Measure Heterangiums was in part due to the discovery, in 1912, by Mr. Lomax, of a fine specimen of *Heterangium* from the coal-balls of Shore, Littleborough. This plant presents some remarkable features, and has aided in the interpretation of other forms ; it will be taken first in the description.

The important discoveries of Dr. Kubart (1908 ; 1911 ; 1914), who has investigated a number of forms of *Heterangium* and *Lyginopteris** from Upper Silesia, also render a survey of the British Coal-Measure species desirable. A consideration of Dr. Kubart's results (as yet only published in a preliminary form) will be postponed to the end of the paper ; at the same time the species of Permo-Carboniferous age, previously discovered by Renault, will be dealt with.

Some interesting points of comparison with the Lower Carboniferous genus *Rhetinangium*, discovered by Dr. Gordon (1912), also arise.

* Potonié's name is adopted in preference to the familiar *Lyginodendron*, Gourlie, for reasons fully set forth in Seward's 'Fossil Plants,' vol. iii. pp. 36-38 (1917).

Heterangium shorense, sp. nov.

The one specimen on which this species is based was discovered by Mr. Lomax and his son on August 12, 1912, in material from Shore, Littleborough. The fragment was 1·5 inches (3·75 cm.) long, and a series of 15 transverse sections was cut (now numbered 2781–2795 in my collection). It is a fine stem, 17–18 mm. in diameter, the wood of the stele, though almost without secondary thickening, reaching 7 mm. in diameter (Pl. **1**. Phot. 1; Pl. **3**. fig. 1). The general outline of the stem is approximately circular, with more or less marked prominences where a leaf-base is met with.

The cortex is for the most part well preserved; it is 3–4 mm. thick. A considerable part of the pericycle is also preserved, often in contact with the inner edge of the cortex. The phloem has almost wholly perished; the gap between pericycle and wood was no doubt caused partly by shrinkage and partly by actual destruction of tissue.

Stele.

We will at first confine our attention to the wood, which in three of the sections is almost or quite complete (Pl. **1**. Phot. 1; Pl. **3**. fig. 1). The great feature of the primary xylem (and little else is present) is the grouping of the tracheides in a large number of definite packets, separated by a narrow reticulum of conjunctive parenchyma. The tracheal packets commonly contain from 6–15 elements each, and range from about 400 to 650 μ in diameter. In the middle part of the wood they are fairly isodiametric, while towards the periphery they become lengthened in the radial direction. These peripheral groups are very distinct, as is usual in the Coal-Measure species. The deep clefts between them, seen in some places, are merely due to shrinkage. The surface of the wood is somewhat ribbed, the peripheral groups being convex (fig. 1).

The parenchymatous reticulum between the tracheal packets appears narrower than it should be, owing to a partial collapse of the cells.

The tracheides of the metaxylem are generally of large size; there is, of course, much variety, but we may take 200 μ as an approximate mean diameter. Towards the outside, *i. e.* in the neighbourhood of the protoxylem of the peripheral strands, the tracheides become rapidly smaller, down to 25 μ or 20 μ. The preservation is such that it is not, as a rule, easy to determine the position of the actual protoxylem. Where this can be fixed it is found near the outside, separated by from two to four small elements from the outer edge of the wood (Pl. **3**. fig. 5). The question may still arise whether all these centrifugal xylem-elements were really primary, for a certain amount of secondary growth had taken place—at least locally. On one side of the stele there are a few irregular layers of radially arranged tracheides—at most five in a radial row (fig. 6). These secondary elements are little larger than the smallest primary tracheides—about 25–35 μ in diameter. On other parts of

the circumference no secondary xylem can be distinguished. Thus secondary growth had just started, the newly formed elements being, as usual, small, corresponding rather to the centrifugal primary tracheides on which they abut, than to the wide elements of the metaxylem.

The primary structure of the peripheral strands was thus, as we should expect, mesarch, but with the centrifugal portion of the primary xylem very small in amount (fig. 5).

Deferring the important subject of the leaf-traces, we come next to the pericycle, for the phloem is practically lost.

The inner margin of the pericyclic zone is more or less crenulated, its concavities corresponding to the convexities of the xylem cylinder (fig. 7). Hence they must originally have fitted on to each other, with the intervention of the phloem only. Now they are almost everywhere separated by a wide gap, containing some Stigmarian rootlets. In places some thickness of thin-walled tissue is preserved; its inner portion may include some remains of the phloem (fig. 6). In other places the pericycle is represented almost wholly by sclerotic tissue, most of the elements having apparently very thick walls, like those of the sclerotic cell-plates in the cortex. In the pericycle, however, the sclerotic tissue is less continuous, a certain number of thin-walled elements being interspersed. In these more resistant parts of the pericycle the crenulations are specially well marked, the sclereides extending into the projections between the hollows (Pl. **3**. fig. 7). The pericyclic sclereides are unusually abundant in *Heterangium shorense*, forming extensive tracts, but they occur also in most of our other Coal-Measure forms.

Cortex.

The cortex, as in other *Heterangiums*, may be divided into inner cortex and hypoderma—the former, of course, much wider than the latter. The inner zone consists of a matrix of thin-walled parenchyma, in which great sclerotic plates are imbedded (Pl. **3**. figs. 1 & 7). These plates sometimes border on the pericycle, and elsewhere may almost reach the hypoderma. As a rule they consist, as seen in transverse section, of hexagonal cells with their lumina more or less completely blocked with a brown substance, which may be altered cell-wall. In other cases the sclereides are flattened and ranged in regular rows, suggesting the activity of a special meristem. These appearances are like what we find in other forms, in *longitudinal* sections through the sclerotic plates, and are no doubt seen owing to displacement of certain of these plates.

The great development of the cortical sclerotic masses is characteristic of, though not peculiar to, the Shore *Heterangium*. The thin-walled cortical tissue between the plates often consists of large cells tangentially dilated; in other places the cells are hexagonal and small, resembling those of the sclerotic plates in form and size.

In the hypoderma the radial bands of sclerenchyma are well marked, and sometimes anastomose across the intervening tracts of cellular tissue, as in *Lyginopteris*. On the prominent leaf-base the proportion of sclerenchyma to parenchyma is greater than elsewhere (Pl. **3**. fig. 2). The leaf-base is delimited on either side by a barrier of sclerenchyma, resembling that of the hypoderma on which it abuts (figs. 1, 2). The whole structure of the cortex is typical of a *Heterangium* and shows the various tissues in a well-developed form.

The elements commonly described as "secretory sacs" are, however, obscure. There are a certain number of cells, especially in the cortex, with dark contents, but, owing to the state of preservation and the absence of any longitudinal sections, it has not been possible to distinguish with certainty between differentiated sacs and disorganised cells.

The Leaf-traces.

We now come to the most characteristic point in our plant—the arrangement and course of the leaf-traces. Several traces are present in each transverse section, but no one section shows them all perfectly. That represented in fig. 1 may serve to give an idea of their distribution. Four leaf-traces are shown in the section.

At the top of the figure is the large leaf-base, in which three bundles are preserved (Trace A). The full number, however, is four, as shown in fig. 2, which represents the same leaf-base several sections higher up the stem. All four are likewise shown in a section cut lower down than that represented in fig. 1, so the presence of three only in the latter is merely due to accidents of preservation.

The first fact, then, which we learn as to the leaf-traces is that no less than four bundles entered the base of the leaf.

In the petiole itself still further division took place, as shown in fig. 3, which represents the section of a detached petiole clearly belonging to the same plant. Here each of the four original bundles has divided into two, the division being more advanced in the middle than in the lateral pairs. This plurality of bundles is a new feature for the genus *Heterangium* and a marked difference from the Lower Carboniferous species, *H. Grievii*, where only a single bundle enters the petiole.

How, then, do the four bundles entering the leaf-base originate? Turning to fig. 1, we see in the "S.E." of the figure, in the inner cortex, a pair of bundles close together, and above them another, ill-preserved, pair. In other sections this second pair is quite well shown; the space between the two pairs is about 1·6 mm. There is thus a strong presumption that the two pairs of strands together constitute a single leaf-trace (Trace B). This is confirmed on observing the bundles on the left of the figure (Trace C). There are two on the inner edge of the cortex, and each is evidently in the act of division. The lower of the two is shown on a larger scale in fig. 6. The

two strands are about 1·2 mm. apart. The whole is evidently one leaf-trace, the two constituent bundles just dividing to form the four seen in traces further out. Lastly, just above the stele in fig. 1, we see two strands (Trace D) lying loose in the empty space between wood and pericycle. This tells us little, but in other sections the same pair is found in connection with the stele. This is shown in fig. 4, from the 3rd section below that from which fig. 1 was drawn. Here the two bundles are just detaching themselves from the wood of the stele, with which they are still in continuity. (See also Pl. **1.** Phot. 1, which shows the same trace in an adjacent section.)

We see, then, that in *H. shorense* two strands left the stele, that they divided into four in passing through the inner cortex, entered the leaf-base as a 4-bundle trace, and underwent further division in the petiole. The middle bundles, in fact, begin to show signs of division before the leaf-base separates from the stem.

Although the available piece of stem was one and a half inches long, the changes in this length are but slight, and the comparison of the successive sections has only shown a fraction of the course of each leaf-trace. Thus, in the case of the four bundles entering a leaf-base (Trace A, fig. 1), the latter becomes decidedly more prominent as we follow the series upwards and more cut off from the cortex by sclerenchyma. The bundles, however, are four in number all through, and, beyond moving outwards and showing some signs of further division, undergo little change.

Trace B, which is somewhat difficult to follow owing to defects of preservation, is a 4-bundle trace from the bottom of the series ; following the trace upwards, the two pairs separate widely from each other, and those of each pair also diverge, but the stage shown in trace A seems not to be reached within the series.

Trace C first appears as a 2-bundle trace, each bundle showing signs of division. The division becomes complete as we follow the trace upwards, but that is about the only change.

The trace D, which is seen starting from the stele in the lower sections, cannot be followed continuously owing to damage. At the top of the series, however, what appears to be the same trace appears in the pericycle, each of the two bundles showing signs of division.

Piecing together the evidence from the various traces, the whole course becomes clear, as explained above—namely, a double trace leaving the stele and further dividing into four bundles before entering the leaf-base.

A word may be added as to the free petiole (fig. 3). It runs practically through the whole series, with little or no change. The transverse section measures about $12 \times 5{\cdot}5$ mm. It is concave on one side, convex on the other, the former having no doubt faced the stem.

The structure is the same as that of the leaf-base attached to the stem, excepting only the further subdivision of the bundles. In the two lateral bundles the xylem is divided, but still in connection. In the middle bundles the division is complete, the ground-tissue already separating the daughter-bundles of each pair (fig. 3). The structure of each bundle appears to be the same as in the xylem-strands of the stem, *i. e.* mesarch with little centrifugal wood. There is no appreciable change in the arrangement of the bundles throughout the series. The ground-tissue of the petiole, like that of the leaf-base, consists of large-celled parenchyma, in which plates of sclerotic cells, and also isolated elements of the same kind, are embedded.

The hypoderma is much thicker on the convex than on the concave side. On the former it is composed chiefly of thick-walled elements, with narrow radial bands of parenchyma at intervals resembling the hypoderma of the leaf-base. The thin layer of hypoderma on the concave side of the petiole seems to consist entirely of sclerenchyma, with smaller cells and thicker walls than that on the opposite face. Towards one end of the specimen (that corresponding to the lower end of the stem-fragment) the hypoderma on the concave side dies out. This is probably merely a matter of preservation, but it is possible that in this part the petiole or leaf-base was originally attached to its stem.

The characters of the new species (for as such it must be reckoned in the absence of evidence to connect it with any other form) may be summed up as follows :—

Heterangium shorense, sp. nov.

Stem large, reaching a diameter of 18 mm. in the one specimen known.

Primary wood arranged in small definite packets, separated by a reticulum of parenchyma.

Secondary wood small-celled (little developed in the specimen).

Peripheral xylem-strands and leaf-trace bundles mesarch, with little centrifugal wood.

Sclerotic tissue highly developed, both in the pericycle and inner cortex.

Leaf-trace consisting of two bundles where it leaves the stele, dividing into four on entering the cortex, and further dividing into eight in the leaf-base and petiole. The traces of at least four leaves present in each transverse section of the stem. Leaf-traces traversing the stem for a long distance before passing out.

Locality. Shore, Littleborough, Lancashire : Lower Coal Measures.

Found by Messrs. James and Joseph Lomax, August 1912.

HETERANGIUM TILIÆOIDES, Will.

The anatomy of the stem of this well-known species from the Halifax Hard Bed has been fully described (WILLIAMSON, 1887; WILLIAMSON & SCOTT, 1895) and need not be recapitulated here. The species is remarkable for the great development of the phloem, sometimes equalling that of the secondary wood, and for the characteristic form of the main phloem-rays, dilated outwards like those of the Lime Tree. The specimens are among the most beautifully preserved of petrified plants, so far at least as the stelar tissues are concerned.

Only three points demand our attention—the course of the leaf-traces, the adventitious roots, and the specific distinction from other members of the genus.

The Leaf-traces.

No satisfactory account of the course of the leaf-traces has ever been given. WILLIAMSON, in his original description of the species, mentions and figures "ascending vascular bundles grouped in pairs" (WILLIAMSON, 1887, p. 290), and further speaks of "the twin bundles going off to what, both in this plant and the allied *Heterangium Grievii*, I presume to have been petiolate leaves" (*l. c.* p. 293).

In our joint memoir (WILLIAMSON & SCOTT, 1895, p. 763) it was recognised that the twin bundles with secondary wood just leaving the stele, already figured by WILLIAMSON in 1887, represent a double leaf-trace. Thus the trace was shown to start as a pair of distinct bundles. On the other hand, the conjecture that "the twin bundles may have completely fused on entering the leaf" has proved to be incorrect. The reverse is the case.

Beyond the fact that the leaf-traces were double, nothing definite was, in fact, established as to this part of the anatomy of *H. tiliæoides*.

Thanks to the kind help of Prof. F. W. OLIVER and Prof. F. E. WEISS in lending slides from their collections, I have been able to examine most, if not all, of the sections of this species in this country. Good as the sections are for anatomical details, the material is not particularly favourable for following the course of the leaf-traces. This is owing partly to the absence of continuous series of sufficient length and partly to the fact that in this species the cortex is usually the worst-preserved region of the stem, so that the leaf-traces are imperfectly shown in the outer part of their course. Still, it has been possible to determine the essential points.

The sections of *H. tiliæoides* which have come under observation appear to belong to four distinct stems, reckoning only those which clearly belong to this species. Three of these are represented in the Williamson Collection, and sections from them are described and figured in his original memoir of 1887. These may be regarded as types. The fourth specimen is represented in my own collection and that of the Manchester Museum. A synopsis of

all the sections known to me is given in a footnote *. The four stems will be shortly referred to as

Specimen 1 (Williamson, slide 1301 etc.).
Specimen 2 (Williamson, slide 1302 etc.).
Specimen 3 (Williamson, slide 1620 etc.).
Specimen 4 (Scott, slide 1323 etc.).

Specimen 3 is the only one which affords a fairly long series of transverse sections. I have succeeded in determining the order of the 10 sections (from various collections) and find it to be as follows, *from below upwards*:—Q. 60; R. 658; Q. 59; N. 12; W. 1620; W. 1624; W. 1623; W. 1625; Q. 58; R. 634.

Two leaf-traces are shown; the divergence between them would be consistent with a $\frac{2}{5}$ phyllotaxis. At the bottom of the series the inner trace (T. 1) is scarcely beginning to leave the stele; it consists of two distinct strands which, however, are here almost in contact laterally (Pl. **3**. fig. 8, from the 4th section). As they pass out through the pericycle they separate rapidly, and gradually lose their own secondary tissues, while those of the stele close in behind them. At the top of the series (the ninth section, Q. 58, is the last which shows this trace complete) the bundles are 2 mm. apart and are in the middle of the pericycle, in which they cause two marked projections. They show, however, no sign as yet of further division.

At the bottom of the series the outer trace (T. 2) is about as advanced as the inner trace was in the uppermost section. In the 2nd section the two

* In the following list the letter W. indicates the Williamson Collection in the British Museum (Natural History); the letters Q. & R. the collections of the Manchester Museum, Q. being the Cash, R. the Hick Collection; S. indicates my own collection; and N. that of the Botanical Department of University College, London (*Heterangium* slides).

Specimen 1.—2 transverse sections, W. 1301; R. 632.

Specimen 2.—6 transverse and 7 longitudinal sections. Transverse: W. 1302, 1303, 1619; Q. 55, R. 654; S. 237. Longitudinal: W. 1304, 1621, 1622, 1627, 1628; Q. 56, R. 631 (?). All these sections appear to be from the same stem, a point not recognised in the joint memoir (Williamson and Scott, 1895, p. 778).

Specimen 3.—10 transverse sections: W. 1620, 1623, 1624, 1625; Q. 58, 59, 60; R. 634, 658; N. 12.

Specimen 4.—2 transverse and 2 longitudinal sections. Transverse: R. 633; S. 1323. Longitudinal: S. 238, 1324.

The order of the transverse sections, so far as it could be determined, is given in the text.

The above list is limited to stems from Halifax. There is a Dulesgate specimen (slides S. 625 & R. 639) which bears some resemblance to *H. tiliæoides*, but seems to be really referable to *H. Lomaxii* (see pp. 77, 79, 82).

A small stem from Halifax, collected by the late Mr. Spencer (sections S. 239, S. 1322; N. 2 *a*, N. 2 *b*) may be a young specimen of the same species.

bundles are quite in the outer part of the pericycle, each occupying a very marked protrusion of this zone. They are about 1·3 mm. apart, and each bundle is tangentially widened and slightly concave on the outer surface—indications of approaching division. The bundles are shown in fig. 8 from the 4th section (N. 12) where the pericyclic bulges are very prominent, and the preparations for division of the bundles evident. Two sections higher up the bundles have left the pericycle altogether, and are now in the ill-preserved cortex. The further changes consist chiefly in the progress of division in each bundle. The trace is shown in fig. 9 from the 9th section (Q. 58), where each bundle is distinctly double *.

This series shows, then, that the trace leaves the stele as a pair of bundles, which become widely separated as they pass outwards, and that each of these divides into two in the cortex. But the complete division of the two bundles into four is not shown.

This series, however, is of additional interest from the fact that three of the sections contain a detached petiole (Pl. 4. fig. 10). The preservation is imperfect but the structure is fairly shown. On the outside is a rather narrow hypoderma of the "*Sparganum*" type, with the sclerenchyma exceeding the parenchymatous bands in extent. The large-celled ground-tissue contains two sclerotic patches, in one of which the cells are ranged in rows. There are also some scattered elements with contents, which resemble the so-called secretory sacs of the stem.

The petiole measures about 6 × 2·5 mm., and has one side flat, the other convex. The important point is that it contains four distinct bundles (shown in all the sections). They have been displaced by the intrusion of Stigmarian rootlets, but appear to have been in two pairs, those of one pair further apart than those of the other. The xylem of the bundles consists of a mass of large tracheides, with a band of smaller elements on one side—exactly like the strands in the petiole of *H. shorense* (*cf.* fig. 3). The organ is obviously the petiole of a *Heterangium*, and there is no reason to doubt that it belongs to the stem with which it is associated. Its dimensions relative to the stem are about in proportion to those in the Shore plant (*H. shorense*, stem 18 mm., petiole 12 × 5·5 mm.; *H. tiliæoides*, specimen 3, stem, if complete, about 10 mm., petiole 6 × 2·5 mm.).

This specimen, then, establishes the strongest presumption that the petiole of *H. tiliæoides* contained four distinct vascular bundles, confirming the evidence for a quadruple leaf-trace derived from the stem.

To complete the proof it is clearly desirable to observe the structure of a leaf-base still in connection with the stem. This is shown, though

* One of the double bundles is figured by Williamson (1887, pl. 22. fig. 7) from W. 1623, the 7th section.

imperfectly, in a section (S. 237) of specimen 2 * (Pl. 1. Phot. 3). This is a large stem, quite 15 mm. in diameter when complete. Though the internal tissues are so admirably preserved, the cortex, as usual, is in a fragmentary state.

A pair of bundles is very beautifully shown just separating from the stele (Pl. 1. Phot. 3, T. 1; *cf.* Phot. 5). Far out in the pericycle is another pair (T. 2) very widely separated, the interval between the strands being nearly 4 mm. These bundles show some signs of division. What chiefly interests us is the presence of an evident, though badly preserved leaf-base, projecting far out from the stem and beginning to be marked off at the sides by internal bands of sclerenchyma (Phots. 3 & 4). The whole is much damaged, but in the middle part the continuity of the tissues is preserved. The tangential width of the leaf-base is about 7·5 mm. Towards one side of the leaf-base and in its inner part is a distinct pair of bundles; the two strands are about 200 μ apart and separated by ground-tissue. In a corresponding position on the opposite side are the remains of another pair; one of these strands is fairly preserved, the other partly destroyed (Phot. 4, *r.b.*).

The leaf-base, so far as preserved, shows the usual *Heterangium* structure, with a rather narrow hypoderma and large plates of sclereides in the ground-tissue. This specimen proves that four bundles, in two pairs, entered the leaf-base, and thus confirms the evidence of the detached petiole associated with specimen 3.

It may be mentioned that in the section W. 1302, which appears to have been cut just below S. 237, two pairs of bundles are shown in the cortex which are probably the same as those which pass out into the leaf-base just described. Both pairs are shown in Williamson's fig. 1 (1887) (one pair is marked *u'*, *u'*; the other, not specially lettered, lies on and below the line *p*). The bundles shown in Williamson's fig. 8, on a larger scale, appear to be the former pair.

The main points in the course of the leaf-traces are now clear, but it may be well to summarise the evidence from the remaining sections.

The transverse sections of specimen 2 are not in a series, but appear to run in pairs †. The sections R. 654 and W. 1303 come next each other, the former being below the latter. In R. 654 two traces are shown; the inner is the pair just leaving the stele, shown in Phot. 5. The phase is almost the same as that of the corresponding pair in S. 237 (*cf.* Phot. 3); a better example could not be found. The two bundles of the trace are quite distinct as regards their primary xylem, but close together; they are separated from

* This is the magnificent specimen from sections of which most of the figures of *H. tiliæoides* in Williamson's memoir of 1887 were drawn.

S. 237 was cut for me by Mr. F. Chapman from the original block, next to W. 1302 shown in Williamson's fig. 1 (1887).

† W. 1302 and S. 237 have already been dealt with.

the metaxylem of the stele by a few layers of conjunctive parenchyma, in which some tangential divisions have taken place. The secondary wood proper to the double leaf-trace is still continuous, but the arcs corresponding to the two bundles are already evident. Most of the phloem is perfectly preserved; it about equals the secondary xylem in thickness.

In the outer part of the pericycle there is a second trace; the two strands are wide apart (about 4 mm.) and each is preparing to divide. In the next section (W. 1303) the inner trace has moved out into the pericycle; the two strands are now diverging, each has its own arc of secondary wood and bast. These bundles were admirably figured by Williamson (fig. 5, 1887) at a time when their leaf-trace nature had not yet been recognised. The outer trace is here in the cortex, but only fragments are preserved.

The two sections W. 1619 and Q. 55 are similar and must have been cut near together, but I cannot exactly correlate them. In W. 1619 no leaf-trace is starting from the stele—the appendage shown is no doubt an adventitious root (figured by Williamson, fig. 13, 1887). Two double bundles are seen in the cortex, just beyond the pericycle. They are about 6 mm. apart, but may have been displaced; they probably belong to the same trace. Q. 55 shows two leaf-traces. The inner is in the pericycle—one strand has been displaced. These bundles have almost lost their arcs of secondary wood, and are therefore at a more advanced phase than those described in W. 1303. The other trace is represented by a double bundle in the cortex—the companion pair is no doubt lost, for much of the cortex is destroyed.

Of specimen 1, I only know of two sections, one in the Williamson and one in the Manchester Collection (W. 1301 and R. 632). Both are transverse and cut close together, R. 632 being just above W. 1301. The specimen is exceptional as regards preservation, for the cortex is fairly preserved, while the pericycle is almost destroyed. W. 1301 shows three leaf-traces and a leaf-base. The innermost (Trace 1) consists of a pair of strands, separated by some conjunctive tissue, about to depart from the stele. A pair of widely diverging bundles (Trace 2) is seen in the pericycle, and a damaged one (Trace 3) in the cortex. The leaf-base or petiole in connection with the stem was described in the joint memoir by Williamson and myself (1895, p. 763). Only one bundle is shown, but, as the section of the petiole is longitudinal, this proves nothing as to the total number present. The conjecture as to fusion of bundles was certainly wrong, as shown by the evidence from specimens already described (p. 68).

The other section, R. 632 (Phot. 2), shows the same leaf-traces. Trace 1 has scarcely moved. The two strands, though only just separating from the wood of the stele, are about 370 μ apart, showing clearly that the bundles are distinct at their origin. Of trace 2 only one bundle is preserved; it lies on the border of pericycle and cortex, and is dividing. Trace 3 is in the inner

cortex ; all four bundles are shown, forming two pairs, about 2·5 mm. apart. The strands of each pair are quite separate, with about 200 μ of cortical tissue between them. The section is important, as proving the complete division of the leaf-trace into four while in the cortex ; unfortunately one of the pairs of bundles is damaged (see Phot. 2). The attached leaf-base is still shown, but no bundle is visible. The three traces and leaf-base mark the position of four successive leaves : their arrangement is in agreement with a $\frac{2}{5}$ phyllotaxis.

There are two transverse sections of specimen 4 (S. 1323 and R. 633) ; they were cut near together. It is a beautiful specimen of a young stem, showing all the stelar tissues perfectly (Pl. **1**. Phot. 8, & Pl. **4**. fig. 12), but, owing to the loss of the cortex, is not of much value for the course of the leaf-traces. In the not quite complete sections two traces are shown, both in the pericycle. In the lower section (S. 1323) the inner trace (T. 1) lies in the inner part of the wide pericycle, and consists of two bundles nearly 1 mm. apart. They have no secondary wood at this level, but it is not much developed on the stele itself. Behind them the stelar wood is beginning to close up in the form of small tracheides, which for the most part run horizontally. The outer trace (T. 2), at about $\frac{2}{5}$ divergence from the former, lies in the extreme outside of the pericycle, which forms a great protrusion round each of the two bundles ; they are over 2 mm. apart (Phot. 8). In the upper section (R. 633) the strands of the inner trace are about 1·5 mm. apart, but there is otherwise little change.

Taking the whole of the evidence from the four specimens, we arrive at the following conclusions regarding the course of the leaf-traces in *H. tiliæoides*.

Two distinct strands start from the stele to form a leaf-trace. Each has at first its own secondary tissues, which it loses in traversing the pericycle.

The strands diverge rapidly, and before the pericycle is passed each begins to divide. The division is completed in the cortex, and four bundles enter the leaf-base and petiole. It will be noticed that the facts are essentially the same as in *H. shorense*, except that in *H. tiliæoides* no further subdivision of the four bundles in the petiole has been observed. This may merely be correlated with the smaller size of the specimen. The phyllotaxis appears to be $\frac{2}{5}$.

Adventitious Roots.

The evidence as to the roots of *Heterangium* is meagre *. It is therefore of interest to find that in *H. tiliæoides* the structure of the root can be determined with a near approach to certainty, a point not hitherto noticed. The best evidence is provided by specimen 3. At the bottom of the series (Phot. 7 ; section Q. 60) the stem bears an appendage (*r.*) embedded in the

* See Williamson & Scott, 1895, pp. 764, 765 ; Scott, 1909, p. 410.

cortex, which from its structure is evidently an adventitious root. In the 2nd section a similar root (Pl. **1**. Phot. 6, *r.x.*) is shown still connected with the wood. Immediately to the outside is a free root cut transversely (*r.*). It is tetrarch, with a considerable amount of secondary wood, and most of the cortex is preserved. This root reappears in the next two sections, but its connection with the stem is not shown. It agrees, however, as nearly as one can expect, with the root-base attached to the stem, and there is little doubt that the free root also belongs to the latter. The drawing (Pl. **4**. fig. 11) is taken from the 4th section (N. 12). Here also the root seems to be tetrarch, the four protoxylem-groups corresponding to four principal rays. The secondary wood is well developed. Where it is cut somewhat obliquely the tracheides show the multiseriate pits on their radial walls as in the stem. The cortex contains a certain number of cells with dark or brown contents. So far as can be observed, the structure of the root is of the "*Kaloxylon*" type. The characteristic double peripheral layer is not shown, but may have been lost. The connection with the stem of *H. tiliæoides,* though not strictly proved, is, as we have seen, beyond measurable doubt.

A very clear root-base in connection with another specimen was figured by Williamson (1887, pl. 23. fig. 12). The appendage shown in his fig. 13 was no doubt of the same nature.

Specific characters.

Nothing is more difficult than to fix the value of anatomical characters in discriminating species, especially in the case of petrified specimens, where practically no other characters are available.

Heterangium tiliæoides is most probably distinct from the other forms described in this paper, but an anatomical diagnosis is not easy to draw up. A few characteristic points may be recalled.

The primary wood has the tracheides grouped in packets, not unlike those of *H. shorense*, but on the whole less regular (Phots. 2, 3, 6, & 7).

The pits on the tracheides both of the metaxylem and secondary wood commonly have a marked spiral arrangement, often with definite spiral bands between the rows of pits (Williamson & Scott, 1895, p. 764).

The great development of the phloem and the presence of large dilated phloem-rays are perhaps the chief characters, but are of course only recognizable in the more advanced specimens *. The phloem may equal or exceed the secondary wood in thickness. Thus, in specimen 4 (a young stem) the secondary wood is about 160 μ thick and the phloem about 200 μ at the same place; at another point they are just equal (245 μ). In an older stem (specimen 2) the secondary wood ranges from about 570 μ to 900 μ in thickness, the phloem from about 650 μ to 740 μ.

* For example, they do not help us in determining whether *H. shorense* (a young specimen) is really distinct.

The pericycle is very wide, 820 μ to 900 μ, in the young specimen 4 (Phot. 7), and 1·1 to 2·2 mm. in the more mature specimen 2 (Phot. 3). The cells are very frequently found in a state of division, especially in the inner layers, so no doubt this zone grew with the growth of the stem. The pericyclic sclereides are chiefly found in the inner portion; their extent varies much in the different specimens.

The fact that the pericycle is usually better preserved than the cortex (almost wholly lost, for example, in specimen 4, otherwise so perfectly preserved) might be thought to indicate some structural peculiarity. But specimen 1, as we have seen, is an exception, and, where the cortex is found, it has the typical *Heterangium* structure, with plates of sclereides in the ground-tissue and a "*Sparganum*" hypoderma, but not very strongly developed.

The course of the leaf-traces has already been dealt with; while, differing conspicuously from the monodesmic type represented by the Lower Carboniferous *H. Grievii*, it agrees essentially with that of other Coal-Measure forms. The rapidity with which the leaf-traces were given off varies with different specimens. Thus, in specimen 3 there are never more than two traces shown in the transverse section, while in specimen 1 there are as many as four, if we include the leaf-base attached to the stem. It may be worth noting that in *H. tiliæoides* the two strands of the trace, where they leave the stelar wood, are near together, though distinct; in some other Coal-Measure forms they are much wider apart to start with; this, however, affords no certain specific distinction.

It is not perfectly certain that the stem described as *H. shorense* may not be a young specimen of *H. tiliæoides*, but there are several small distinctions, such as the more regular grouping of the metaxylem tracheides in *H. shorense*, the apparently narrower pericycle with sclereides at the periphery, and the division of the leaf-trace into eight in the petiole. As the localities are different, *H. tiliæoides* coming from the Halifax Beds and *H. shorense* from Dulesgate, there is no presumption that they are identical, and it is better to keep the two distinct. The following diagnosis may be given:—

Heterangium tiliæoides, Will.

Stem from about 10 mm. to about 16 mm. in diameter.

Primary wood arranged in more or less definite packets, separated by parenchyma.

Tracheides often with a spiral band between the pits.

Secondary phloem much developed, often equalling or exceeding the secondary wood in thickness. Phloem-rays much dilated.

Peripheral xylem-strands and leaf-trace bundles mesarch, with little centrifugal wood.

Pericycle broad. Sclerotic tissue present both in pericycle and cortex.

Leaf-trace consisting of two bundles where it leaves the stele, dividing into four in the cortex. Four bundles in the petiole. Number of traces in the transverse section from two to four. Traces traversing the stem for a long distance before passing out.

Locality. Halifax Hard Bed, Lower Coal Measures.

HETERANGIUM LOMAXII, *Will. in MS.*

Williamson, in his 17th Memoir (1890, p. 96), states, under the heading *Heterangium Grievii*, that Mr. Lomax had found specimens of the same plant from Dulesgate in Lancashire. He proceeds: "But along with these he brought from the same locality a series of sections of what at first seemed to be a different species of *Heterangium*. But long and careful comparison of all the examples of that genus in my cabinet convinced me that the supposed new forms were merely the *H. Grievii* in a younger state of growth."

The specimens figured and shortly described in the memoir referred to are those in the "younger state of growth" (Williamson, *l. c.* pls. 14, 15. figs. 14–18), which Williamson at first regarded as distinct. He did not describe the other, more advanced form, which he had always considered as simply *H. Grievii.* In the joint memoir (Williamson & Scott, 1895) the Dulesgate forms are only referred to incidentally, but both the younger and more advanced conditions are illustrated for special points (*l. c.* pl. 26. fig. 21; pl. 27. figs. 28, 29). It was no doubt to the younger and more peculiar form that Williamson's unpublished MS. name of *H. Lomaxii* was intended to apply. In the joint memoir we also described and figured "a *Heterangium* of uncertain species," from Dulesgate, and provisionally named it *H. cylindricum* (*l. c.* p. 764, pl. 28. figs. 30, 31).

There are therefore three forms of the Dulesgate Heterangiums which have already been recorded.

1. The young stems with little or no secondary thickening. This form will be called α (Pl. **4**. figs. 16, 17).
2. The older stems, with well-marked secondary tissues, resembling *H. Grievii*, now to be called the β form (Pl. **2**. Phots. 9, 11, 12, 13).
3. The so-called *Heterangium cylindricum** (Pl. **2**. Phot. 14).

After careful comparison of all available sections I have come to the conclusion that all the above, including one or two minor variants, belong to one species (of course, quite distinct from the Lower Carboniferous *H. Grievii*), to which the name *H. Lomaxii* is collectively applied. The only Dulesgate

* All the specimens of these three forms appear to have come from one coal-ball. This is Mr. Lomax's recollection, and it is confirmed by the uniform character of the matrix in which the stems are imbedded. The single specimen of *Heterangium minimum* (see below) came from a different block. It is remarkable that no new specimens of *H. Lomaxii* have been met with since the original discovery by Mr. Lomax about 1890. The species must have been very rare or the conditions for its preservation very unfavourable.

Heterangium which it is proposed to keep distinct is the little stem described in a subsequent section of the paper under the name *H. minimum* (p. 90). The reasons for the conclusions arrived at will appear in the course of the description. I take the β form first, because the best specimens belong to it, and it has never been properly described. Its relation to the α form is not very obvious, though I think Williamson was right in uniting them.

H. Lomaxii, Form β.

The specimens of this form are associated with those of the α form and of "*H. cylindricum.*" All appear to have come originally from the same block. I have enumerated in the footnote * seven specimens of the β form, though more than one may possibly belong to the same stem, as in the case of 5 and 6.

The preservation of the outer tissues is seldom so complete as to render any very accurate measurements of the stem practicable. Roughly speaking, the dimensions of the different specimens range from 17×10 mm. to 7×4 mm., or, allowing for compression and distortion, the diameter may be said to vary from about 13 mm. to about 5 or 6 mm.

The general form of the stem, to judge from the least-distorted specimens, seems to have been nearly cylindrical. The leaves appear to have been, as a rule, borne on the stem at long intervals, for many of the sections show the trace of only one leaf, and unfortunately no section happens to pass through an evident leaf-base in connection with the stem. The best-preserved specimen is No. 5 (Pl. **2**. Phot. 13); from the considerable development of the phloem, this stem at first sight recalls *H. tiliæoides,* but from its structure must be referred to *H. Lomaxii.*

The Stele.

The more or less compressed primary wood varies in the different specimens from 8×2 mm. to 3×1 mm.—say, from 4 or 5 mm. to about 2 mm. in diameter if restored to its presumably cylindrical natural form. Its size is by no means always proportional to that of the stem, owing to large differences in the development of the secondary tissues.

The arrangement of the metaxylem tracheides is not very regular (Pl. **2**. Phots. 9, 12), the groups being less definite in form and size than those of

* For reference letters see above, p. 67.

Specimen 1.—7 transverse sections: W. 1915, 1915 A, 1915 B, 1915 C; Q. 6, Q. 11; S. 447.

Specimen 2.—3 transverse sections: W. 1915 H; Q. 64; S. 445.

Specimen 3.—7 transverse sections: W. 1304 A, 1915 P; R. 621; S. 444, 446; N. 7, 19. The longitudinal sections W. 1915 G and 1915 R probably belong to this specimen; possibly R. 638 also.

Specimen 4.—2 transverse sections: W. 1915 R; R. 645.

Specimen 5.—2 transverse sections: R. 639; S. 625.

Specimen 6.—3 transverse sections: W. 1915 D, 1915 E, and probably N. 3.

Specimen 7.—2 incomplete transverse sections: R. 1057; N. 8.

Where necessary, the order of the sections in a series is given in the text.

H. shorense or even *H. tiliæoides.* Sometimes (as in specimen 5, Phot. 13) the amount of xylem-parenchyma is considerable. The peripheral xylem-groups are very distinct, the radial bands of parenchyma between them being continuous with the principal rays of the secondary wood (Pl. **2**. Phots. 9, 12; Pl. **4**. fig. 13). In this point the present species agrees with *H. tiliæoides* and *H. shorense* *, and differs from the Lower Carboniferous *H. Grievii*, in which the peripheral strands are less isolated and the secondary wood not divided up by principal rays.

Another feature of *H. Lomaxii*, which it shares with other Coal-Measure forms, is the position of the protoxylem, which lies very near the outside of the primary xylem, with only one or two centrifugal elements before the secondary wood is reached. Thus the peripheral xylem-strands, though still mesarch, are approaching an exarch structure (see Phot. 10). This, again, is a marked difference from *H. Grievii*, where the centrifugal part of the primary wood is considerably more developed (see Williamson & Scott, 1895, pl. 26. figs. 24, 25 †). The position of the protoxylem in *H. Lomaxii* is well shown in longitudinal section in Pl. **4**, fig. 14, where the laxly coiled spiral element, which is no doubt the true protoxylem, is succeeded to the outside by a single, more closely wound spiral tracheide, beyond which the wood appears to be secondary. On the inside the pitted elements are reached at once. Often, however, there is a little parenchyma on the inner side of the protoxylem. It appears that here, as in *Lyginopteris* and *Heterangium Grievii,* the centrifugal part of the xylem was the first to be formed after the protoxylem.

Elements with dark brown contents are very frequent in the xylem-parenchyma, the rays, and throughout the stele. Whether they can be properly called "secretory sacs" is doubtful. They do not show, as a rule, any special elongation as compared with the associated cells. They are best shown in the rays, where they run in a radial direction; here their contents are sometimes in the form of a mass of granules, simulating altered starch-grains, but very variable in size. The "secretory" elements were mentioned in the joint memoir as characteristic of the Dulesgate specimens ‡.

The secondary wood varies greatly in amount, not only in the different specimens, but in different parts of the same specimen; it sometimes attains a very considerable development. Thus, in specimen 5, the thickness of the secondary wood ranges from 0·61 to 1·64 mm. (Pl. **2**. Phot. 13). In specimen 1 the range is even greater, varying in one transverse section (S. 447; Phot. 9) from 0·3 to 2·58 mm. The excessive thickness at certain places is correlated with the presence of adventitious roots, as was already remarked in the joint

* In the latter, the specimen is too young to show the relation to the principal rays.

† This distinction was noted in the joint memoir, *l. c.* p. 750.

‡ Williamson & Scott, 1895, pp. 748, 752.

memoir of 1895*. In other specimens the secondary growth has made little progress. Thus in a section (W. 1915 P) referred to specimen 3, the thickness ranges from ·08 to ·3 mm. only, and in specimen 2 it is about the same (see Pl. 4. fig. 13). These relatively young specimens are of interest for comparison with the unthickened stems included under our form α (see page 85).

As is usual in *Heterangium*, the first-formed elements of the secondary wood are considerably smaller than the primary metaxylem tracheides; further out, if the growth is continued, they generally become larger, though seldom reaching the size of the largest primary tracheides (see Pl. 2. Phots. 9 and 13). Local tangential bands of exceptionally narrow tracheides are frequent.

The structure of the secondary wood is like that of other species of *Heterangium*. The tracheides have the usual multiseriate bordered pits on their radial walls. Where, however, the elements are very narrow, the number of rows may be reduced to two or even, locally, to one. Where the pits are well preserved, we see that the border has a narrow inclined slit. In places the pits show traces of a spiral arrangement, but the definite spiral bands noticed in *H. tiliæoides* have not been observed here.

As I have seen no good tangential section it is difficult to say anything definite about the structure of the tangential walls. Certainly the pits are very few here compared with those on the radial walls, but there is evidence for the occurrence of scattered tangential pits †.

The principal rays—those corresponding to the intervals between the primary xylem-strands—are of considerable width, amounting to 9 or 10 cells in the larger specimens. The secondary rays vary much in width and in some cases appear to be uniseriate. The principal rays are occasionally divided up by intercalated tracheides, at some distance out, and, conversely, new rays appear as the wood increases in thickness. The ray-cells are thin-walled and much elongated in the radial direction.

The phloem is fairly preserved in one case only, specimen 5 (see Phot. 13). It here attains a maximum thickness of about 0·8 mm. I have not found such marked dilation of the phloem-rays as characterizes *H. tiliæoides*. The secondary phloem consists for the most part of fairly large, radially arranged elements. A small-celled irregular tissue sometimes preserved on the outer border is no doubt the primary phloem. In the absence of satisfactory longitudinal sections no details of the phloem-structure can be given.

The pericycle forms a broad zone, and is often better preserved than the cortex, as in *H. tiliæoides* (Phots. 9, 12, 13). Its normal width, apart from bulges where bundles or roots pass out, is about 0·6 mm. in specimens 1 and 6, where it is best shown.

* Williamson & Scott, 1895, p. 757.

† *Cf.* Williamson & Scott, 1895, p. 752.

Sclerotic groups are frequent in the pericycle: in most stems they are quite conspicuous; in specimens 5 and 6 they are not so easy to find, but this seems to be only because their cell-walls are less thickened. The sclereides are short elements, but (to judge from the longitudinal section R. 638) appear to form vertical strands of considerable length. The pericyclic parenchyma consists of short cells, many of which have the dark contents above referred to.

On the outer border of the pericycle tangential divisions have sometimes taken place, giving rise to a tissue resembling an internal periderm, such as we find in *Lyginopteris* *. This is best shown in specimen 1 (*e. g.*, S. 447).

The cortex is well preserved in certain cases, though often the parenchymatous part of the inner zone has perished, with the result that the *Sparganum* hypoderma is sometimes stripped off. When the parenchyma is preserved it consists of large, short, thin-walled cells. Here, as in other species, the sclerotic plates of the inner cortex are a conspicuous feature. Their transverse diameter may be as much as 1·4 mm. In the descriptions previously given they are confused with the corresponding structures in the true *H. Grievii* †; in reality those of *H. Lomaxii* are quite distinct. They here form massive blocks, rather than plates, reaching a thickness of about 15 cells and 0·6 mm. In the middle part the cells are flat and thick-walled, while towards the upper and lower edges they become longer, with thinner walls. All the cells are regularly ranged in vertical rows (see Pl. 4. fig. 15). Corresponding to their bulky form, the sclerotic masses are rather widely spaced. In *H. Grievii* the plates are much thinner and seldom more than four cells or about 0·2 mm. in thickness; they are also more numerous. The contrast is striking if one compares fig. 15 in this paper with Williamson's figure of *H. Grievii* (Williamson, 1873, pl. 29. fig. 32). *H. tiliæoides* is intermediate in these respects (Williamson, 1887, pl. 22. fig. 11). As regards the sclereides themselves, the apparent thickness of their cell-walls varies much. In some cases it is probable that the walls were not really as thin as they appear, the thickening layers originally present having become altered and obscured.

The parenchyma of the inner cortex consists of rather large, short or slightly elongated, thin-walled cells. The *Sparganum* hypoderma ‡, or outer cortex, varies a good deal in the different specimens. As a rule, we find the usual alternating radial bands of sclerenchyma and parenchyma; the former are commonly broad and not much elongated radially, and thus quite different from those of *H. Grievii* §. The bands sometimes anastomose. In

* Williamson & Scott, 1895, p. 718, pl. 21. fig. 1; pl. 22. figs. 5–7.

† As in Williamson & Scott, *l. c.* p. 753.

‡ The name "hypoderma," though commonly used, is not strictly correct, for the *Sparganum* zone does not border immediately on the epidermis.

§ *Cf.* Williamson, 1873, pl. 28. fig. 30; pl. 29. fig. 35.

the younger stems the parenchymatous strips are narrow; as the stem increased in thickness they widened out somewhat (Phot. 9). In one stem (specimen 5; Pl. 2. Phot. 13) the *Sparganum* structure is absent; all the tissue of the outer cortex, so far as preserved, is thin-walled, and there is little sign of any differentiation. The stem is in an advanced stage of growth, so this peculiarity cannot be explained by youth; possibly this specimen may have been a rhizome or underground portion of the stem.

Beyond the *Sparganum* zone, where it is normally developed, we find two or three layers of cells larger than the sclerenchymatous fibres; they may have either thin or thick walls—the latter especially where they abut on sclerenchyma. In longitudinal section they are found to be elongated, but differ from the fibres in having transverse end-walls; their contents are often carbonaceous.

Lastly, we come to the epidermis, consisting of rather small and thick-walled cells, often remarkably well preserved. I have not, however, succeeded in detecting any stomata.

We have now completed the description of the stem-structure, apart from the leaf-traces. At every point there are differences from the Lower Carboniferous *H. Grievii*, and when once the comparison is made no confusion between the species is possible. The relations of *H. Lomaxii* to the contemporary *H. tiliæoides* are much closer.

The Leaf-traces.

The distribution of the vascular bundles supplying the leaves is perhaps the most important point in the anatomy, and has not previously been investigated in *H. Lomaxii*. The different specimens of the β form show some variations in this respect. We will begin with specimen 1, of which there is a series of 7 transverse sections; the order from below upwards appears to be as follows:

S. 447; Q. 6; W. 1915 C; Q. 11; W. 1915; W. 1915 B; W. 1915 A.

There seems to be a gap between W. 1915 and W. 1915 B, but I believe that the same leaf-trace is present throughout the series.

In the lowest section (S. 447; Pl. 2. Phot 9) there are two large bundles in the pericycle, 2·5 mm. apart*; each bundle causes a marked bulge in the pericycle; on the inner side only one or two layers of cells invervene between the bundle and the ill-preserved phloem of the stele. No other leaf-trace is present, and the two strands are both in the same phase; it therefore seems clear that both must belong to one and the same leaf-trace, for if they were two separate traces one would be further out than the other, and additional leaf-traces would be shown in other parts of the periphery. It might, indeed, be imagined that we have to do with a dorsiventral axis, the leaf-traces being given off from one side only as, *e.g.*, in *Helminthostachys*; in that case it is very unlikely

* The clear interval is measured from xylem to xylem.

that leaves and roots would be borne on the same side of the stem, and, as we shall see presently, adventitious roots come off in our specimen between the two leaf-trace bundles.

It thus appears that the leaf-trace was a double one, with the two strands very far apart.

The bundles are unusually large, the xylem of each measuring at least 1·4 by 0·8 mm.; each has a concavity on the outer side and is intersected radially by a band of narrow elements (parenchyma?), suggesting an approaching division, which, however, is never carried out within the series. In this section the wood is much thickest on the side opposite the bundles; this is no doubt due to a previous trace, with its attendant roots, having been given off in that position at a lower level. The inequality diminishes as we proceed upwards, and is finally reversed.

In the next two sections (Q. 6 and W. 1915 C) there is no change worthy of note in the position of the bundles. In the 4th section (Q. 11) one of the bundles has been displaced; the natural interval had increased somewhat, and the strands are also appreciably further out. In the 5th section (W. 1915), while the strands are still no more than 2·7 mm. apart, they have now advanced to a considerable distance beyond the phloem, represented by ten or twelve layers of cells. At this level the secondary thickening is almost equal on the two sides of the stele *.

In the 6th section (W. 1915 B) there is a great change. The same two bundles can be recognized, but they have moved much further apart—the actual interval is 5 mm., and there does not seem to have been much displacement. One bundle is cut obliquely, and lies considerably further out than the other. The pericycle around the bundles is immensely enlarged (about 3 mm. thick). Midway between the two strands an adventitious root passes out horizontally, and can be traced for some distance.

In the last section of the series (W. 1915 A) the bundles are still further separated (6·5 mm. clear interval). One is still much further out than the other, about 1·7 mm. as compared with 0·7 mm. from the stele, but not much importance should be attached to this difference, as the section is here somewhat oblique and the tissues in places damaged. Only the more remote bundle shows signs of division. Both strands are here also imbedded in a great mass of apparently pericyclic tissue (see Pl. **2**. Phot. 11). A fragment of *Sparganum* hypoderma is present on the outside, but no other cortical tissues appear. The whole mass might be taken for a leaf-base, but the bundles are not far out enough for this, and one can only regard the excessive development on this side of the stem as due to the presence of adventitious roots. In this section, as in the last, a root (different from the previous one)

* It is in this section that the young root, previously figured, occurs (Williamson & Scott, 1895, pl. 27. fig. 29). It lies on the side opposite the leaf-trace.

passes out between the two leaf-trace strands; in this case its connection with the wood of the stem is clearly shown. The wood is here more developed on the leaf-trace side than on the other, but is very irregular and many of the tracheides are cut longitudinally.

It is evident, from the last two sections, that a row of adventitious roots was given off between the two bundles of the leaf-trace. This agrees with the evidence from a longitudinal section (W. 1915 G) previously figured and described *. Here three roots are seen in a vertical series; just as in the transverse sections the pericycle "has undergone an enormous thickening, with tangential cell-divisions, around the bases of the roots." The anomalous development of secondary wood in the same region was also mentioned and compared to the "réseau radicifère" of Van Tieghem. In a parallel longitudinal section † of the same portion of stem, the roots are missed, but a leaf-trace bundle is shown in the corresponding position. This was doubtless one of the two bundles flanking the row of roots, as shown in the transverse sections. The longitudinal sections show clearly that the local hypertrophy of the pericycle had nothing to do with a leaf-base, for the leaf-trace strand shown is still running almost vertically and not bending out.

For the reasons already given, I have no doubt that the two bundles shown in the transverse series belong to the same trace; their wide separation may be due to the presence of the roots between them, and it is possible that they may have again converged before entering the base of the leaf.

Throughout the series no other trace-bundles are given off. The seven sections, considering the date at which they were cut, would represent a length of quite an inch, so we may infer that the leaves were widely spaced with long internodes.

Specimen 2 (Pl. 4. fig. 13; S. 445), a smaller stem (about 9 × 8 mm.), likewise shows two bundles only in the transverse section; they are both at one end of the compressed stele, and the interval between them is 1·6 mm. They lie just outside the wood of the stele. No other trace is given off in the three sections of this specimen ‡, all of which show the same two bundles. Between them there are two marked protrusions of the secondary wood, which appear to be composed of short pitted tracheides. These are evidently connected with the insertion of adventitious roots, which are clearly shown in one of the sections (Q. 64). Two of the roots are seen side by side; there may have been a double row, as was possibly the case in the previous specimen also. A huge mass of ill-preserved tissue encloses the roots and bundles.

* Williamson & Scott, 1895, p. 757, pl. 27. fig. 28.

† W. 1915 R.

‡ The order from below upwards seems to be: S. 445, Q. 64, W. 1915 H, but as the two latter are very oblique it is difficult to determine.

In this specimen the arrangement was evidently the same, in essentials, as in specimen 1, the leaf-trace being double, with widely separated strands and roots between them.

Specimen 3 is a little different. In one section (S. 446) the bundles of the one pair shown are only about 0·8 mm. apart; the preservation of the outer tissues is, however, so bad that one cannot be certain that the interval is natural. In a better-preserved section, probably of the same stem (W. 1915 P), two bundles are shown well out in the pericycle and 1·6 mm. apart; each shows signs of division. There is no certain evidence for a second trace in any of the sections. It is evident that this specimen really agrees with the previous two; if the strands of a trace are sometimes nearer together, this may well be due to the absence of adventitious roots between them.

Specimen 4 is of the same type. A pair of bundles lies in the pericycle, 1·64 mm. apart (in R. 645). Between them a root passing out horizontally is beautifully shown. The stem is a comparatively young one; the secondary wood is considerably thicker on the side where the trace and root are, but there is not yet any excessive hypertrophy such as one finds in older stems.

Specimen 5, already referred to for the good preservation of the phloem and the absence of *Sparganum* structure, is peculiar in the character of the leaf-traces. In the section photographed (S. 625; Pl. 2. Phot. 13) two traces are shown, each consisting of two bundles. The inner trace (T. 1) is passing out through the secondary wood; in this position each strand has its own secondary arc. The primary xylem-groups are about 1·6 mm. apart, and are unusually small, about 300 μ and 240 μ respectively in tangential diameter, about half the diameter of those in the smaller stems previously considered. The primary tracheides are also small—only the outer part of the stelar strands appears to have contributed to the trace-bundles. This trace is of interest, for it is the first one we have met with in the act of leaving the wood, and it shows that the bundles were well separated at their first origin from the stele.

The outer trace (T. 2, almost opposite the former) is in the pericycle. It consists of two small strands (about 220 μ in diameter) about 1 mm. apart. They have no secondary wood. In the next section (R. 639), which appears to have been cut about 7 or 8 mm. lower down the stem *, the inner trace has disappeared, having completely fused with the stele. The outer trace is still in the pericycle, the bundles here are larger (about 320 μ) and only about 0·75 mm. apart. They are fully as large as those of the inner trace; so we must assume that these two bundles represent an entire leaf-trace and not the product of any subdivision. The distance between the strands of a pair is evidently a very inconstant feature. In this specimen several adventitious

* This is roughly calculated from the dimensions of a *Trigonocarpus* seen in transverse section in both slides.

roots are present; their position, unlike that of the roots in previous specimens, shows no relation to the leaf-traces.

I believe that specimen 6 is part of the same stem, though the state of preservation is different, the phloem having collapsed. The surrounding objects are the same, and the structure of the stem agrees essentially, especially in the absence of any well-marked *Sparganum* hypoderma. The two sections W. 1915 D & E each show two double leaf-traces too near together for any probable phyllotaxis, but possibly displaced. They are rather small bundles, 300–410 μ in diameter. The main point is that here again two double traces are seen in the same transverse section.

A third section (N. 3) is photographed (Pl. 2. Phot. 12). It is complete, which the two Williamson sections are not, and probably belongs to the same stem, though there is no absolute proof. Two double leaf-traces are shown, at a divergence which may be roughly estimated at $\frac{2}{5}$. One trace (T. 1) is in the outer part of the pericycle, the other (T. 2) may have just entered the cortex. The bundles of each trace are near together * and their relation to each other is obvious. In size they are somewhat larger than in the previous sections (410–490 μ).

The stem just described is a variant on the β type first considered, though the distinctions are not important; the peculiarities are that two traces are usually seen in the same transverse section, that the two bundles of a leaf-trace are usually near together, that the bundles are, on the average, small, and their tracheides also small. It may be added that no regular relation appears to obtain in this case between the roots and the leaf-traces. Considering the poor development of the mechanical tissues it is not improbable that the stem was of the nature of a rhizome.

The β specimens generally establish the fact that the leaf-trace was constantly double from its starting-point in the stele outwards, the two bundles being often remarkably far apart. We have so far no conclusive evidence as to their further subdivision. It may be mentioned that in this species the trace-bundles carry no secondary wood out with them when they enter the pericycle.

Further considerations may be postponed till we have compared the other forms of stem in the species.

H. Lomaxii, Form *cylindricum* †.

In the joint memoir with Williamson this form was provisionally treated as distinct, for it was obviously different from *H. Grievii,* with which the other Dulesgate specimens were at that time confused, while it was not

* Those of the outer trace are evidently displaced, and appear closer together than in nature.

† Williamson & Scott, 1895, p. 764, pl. 28. figs. 30, 31.

identical with *H. tiliæoides*. Now that *H. Lomaxii* is recognized as a distinct species it becomes evident that the "*cylindricum*" specimen is merely a form of it, a fact which Mr. Lomax realized many years ago.

The specimen happens to be of considerable interest. There are six transverse sections (only two of which are good), two longitudinal, and one oblique *. The cylindrical form of the stem is preserved with little distortion, while all the other Dulesgate specimens are more or less compressed. The outer cortex has a curious carbonized appearance, and may have undergone some change which made it more resistant than in other cases.

The best transverse section is one in the University College collection, and is shown in Pl. 2. Phot. 14. The Williamson section previously figured (Williamson & Scott, 1895, pl. 28. fig. 30) is rather less complete, though the cylindrical form is more perfect. The stem is 6·75 × 5 mm. in diameter.

The primary wood is well preserved, and agrees in every respect with that of the specimens of *H. Lomaxii* already described. A few layers of small-celled secondary wood had been added in places. Scarcely any of the phloem is preserved, and in the pericycle only the sclerotic nests persist; their presence, once regarded as distinctive, is of course common to the Dulesgate stems generally. The cortex is quite well preserved—much better than is usual in the β specimens. The masses of sclereides, with radiating cells round them, are conspicuous and have assumed a black colour. The longitudinal sections show that they form solid blocks as in other Dulesgate stems. The *Sparganum* hypoderma has the structure typical for the younger stems of *H. Lomaxii* (see above, p. 78).

The point of real interest lies in the leaf-traces, of which two are shown in the section photographed. The inner pair (T. 1) is only just beginning to separate from the stele, in the outline of which the two strands (each about 700 μ in tangential diameter) form gentle protrusions, cut off at the back by conjunctive tissue. They are quite near together, at an interval of about 120 μ only. This is the earliest stage in the separation of a leaf-trace from the stele which we have yet met with, and it shows again that the two bundles were distinct from their origin.

The outer trace (T. 2), at a divergence of perhaps $\frac{2}{5}$ from the former, is in the cortex and consists of two *double* bundles, about 1150 μ apart. The division of each of the original strands into two is quite evident, and shows that here, as in *H. shorense* and *H. tiliæoides* also, the trace ultimately became a 4-stranded one. A protrusion of the cortex in the region of the leaf-trace indicates the beginning of the base of the leaf.

In the section previously figured (W. 1304 A), which appears to have been

* The six transverse sections, in their probable order from below upwards, are: N. 19; W. 1304 A; R. 621; S. 444; S. 446; N. 7.

The longitudinal sections are W. 1304 B and R. 644; the oblique section is W. 1915 P. When the joint memoir was written, only the two sections W. 1304 A & B were examined.

cut a little distance above the University College section, the outer trace has disappeared, having no doubt passed out into the petiole. The double trace shown (*l.c.* pl. 28. fig. 30, *l.t.*) in the disorganized pericycle corresponds in position * to that which in the former section was still in connection with the wood. At the level shown, the two bundles have not yet begun to divide into four. No other trace is present in the Williamson section.

The other transverse sections afford no new data, but the Williamson longitudinal section (W. 1304 B) is of considerable importance, as it shows a leaf-base in connection with the stem, a point not noticed at the time of the previous description. The preservation of the leaf-base is not very good, but the main features of the structure are clear. The petiole is attached obliquely to the stem, which it appears to exceed in width; the cortical tissues are perfectly continuous throughout. A layer of sclerenchyma, seen in tangential section, forms a partial barrier between stem and leaf-base. The latter has a *Sparganum* hypoderma and sclerotic masses like those of the stem. The important point is that it contains two double bundles or bundle-pairs. They are widely separated, but in each pair the division into two has only gone about as far as in the transverse section figured (Pl. 2. Phot. 14). It appears then, that the leaf-trace passed into the base of the leaf as two bundle-pairs, and not as four independent bundles, thus resembling *H. tiliæoides* rather than *H. shorense*.

The "*cylindricum*" specimen thus throws a good deal of light on the course of the leaf-traces. It does not differ in any essential respect from the other examples of *H. Lomaxii* described, though it does not exactly agree with any of them; the trace-bundles are fairly large, but do not separate very widely from each other in passing through the stem; this is probably because in this case no roots arose between the strands. The leaves were at somewhat long intervals, for in most of the transverse sections only one trace is met with. The "*cylindricum*" stem is evidently a specimen of the rather variable Dulesgate species, *H. Lomaxii*.

H. Lomaxii, Form *α*.

This form was shortly described and admirably illustrated by Williamson in his 17th Memoir (1890, p. 96, pls. 14, 15. figs. 14–18). A section of it was also figured in our joint paper (Williamson & Scott, 1895, p. 753, pl. 26. fig. 21) and shows a branch in connection with the stem; I believe this is still the only recorded case of branching in the genus *Heterangium*.

The specimens are all more or less crushed, and present a rather singular appearance, different from that of most Heterangiums. This is chiefly due to the fact that the cortex, owing to the great development of the sclerotic

* As the two slides are reversed, it is impossible to figure them with corresponding orientation.

masses, is less crushed than the stele. The specimens are closely associated with those of the β form, sometimes appearing in the same sections *.

The stems vary in size. Williamson's type-stem (specimen 1; W. 1915 H) measures about 14·5 × 5·5 mm., with wood (badly crushed) about 6 × 2·5 mm. in diameter. This is only exceeded in size by one of the β stems. Specimen 2 is about the same size, with a smaller branch. Specimen 2 *a* is a little smaller than the first two; while the obscure specimen 1 *a*, of which only the stele is preserved, must have been fairly minute, the wood only measuring about 2·5 × 1·5 mm.

So far as the crushed state of the tissues allows one to judge, the structure of the wood did not differ from that of the specimens already described, unless it be that in the α stems the centrifugal wood of the bundles is sometimes rather more developed. With one partial exception, to be mentioned presently, no secondary wood has been detected.

The pericycle contains sclerotic groups as in other specimens. The cortex is the best-preserved part of the stem, and presents a rather striking appearance owing to its strong mechanical construction, the amount of sclerotic tissue exceeding anything observed in the other forms (see Pl. **4.** figs. 16 & 17, and compare with fig. 13 and Pl. **2.** Phots. 9, 12, 13, 14). The longitudinal sections confirm this (see Williamson's figures, 1890, pl. 15. figs. 17 & 18, and compare fig. 15 here). The sclerotic nests are both large, often exceeding 1·6 mm. in diameter, and numerous. The outer cells are elongated radially to the mass. The hypoderma is well developed, with a preponderance of the fibrous tissue, as is usual in young stems. The epidermis is well preserved in places.

Owing to the crushing of the stele the specimens are unfavourable for following the course of the leaf-traces, for portions of the wood are often mechanically severed from the main mass and may simulate outgoing strands, while genuine leaf-traces may be crushed in and become unrecognizable.

In Williamson's figured specimen (*l. c.* fig. 14) the double strand at *a* may probably be a leaf-trace, but there is no proof. On the other hand, the two double bundles, a little higher up on the left, certainly constitute a trace. They are best shown in a Manchester section (Q. 10) cut just above Williamson's. This is altogether a good section, with the wood rather less crushed than usual; the leaf-trace is particularly clear (Phot. 15). Whether it is in

* The known specimens of the α form are as follows: Specimen 1. W. 1915 H; Q. 10, R. 643, R. 657 (transverse); W. 1915 F (longitudinal) from the same stem. 1 *a*. A smaller stem appearing in the four transverse sections, as above. The larger stem, 1, may be taken as the type (Williamson, 1890, figs. 14–16, 18). Specimen 2. W. 1885 H*, 1885 HH, 1915 M*, 1915 N*, 1915 O; R. 642*; S. 236* (transverse). 2 *a*. A smaller stem occurring in the sections marked * above. Specimen 3. W. 1915 E (transverse); W. 1915 I, 1915 K, 1915 L (longitudinal) probably from the same stem. The order of the sections will be mentioned in the text when necessary.

the pericycle or cortex is hard to say, the two tissues not being at all sharply delimited here—at any rate, it is separated from the disorganized phloem of the stele by several layers of more or less sclerotic parenchyma. The two double bundles of the trace are about 120 μ apart; they are fairly large strands, measuring 615 μ and 820 μ respectively in tangential diameter, and each is manifestly double, for the xylem is lobed and divided radially down the middle by a band of collapsed cells. This section, then, proves that the leaf-trace consisted of two bundles, each of which prepared to divide before it had got far on its outward course. The adventitious root figured by Williamson shows no obvious relation to any leaf-trace.

In specimen 2 the order of the sections from below upwards proves to be: W. 1885 HH, W. 1915 N, W. 1885 H, W. 1915 M, W. 1915 O, S. 236, R. 642. So long a series seems promising, but the stem is in many sections incomplete and the crushed condition perplexing. It is doubtful whether the two "leaf-traces" marked on our fig. 21, of 1895, were really of that nature; the only undoubted trace is near the broken end of the section. In the present fig. 16 (Pl. **4**), from this specimen, the double strand *v.b.* may be a leaf-trace. So far as the evidence goes, it confirms that from the type-specimen.

In specimen 2 *a*, which appears in five sections of the same series, a double leaf-trace can be followed through the whole thickness of the cortex. In the section figured (fig. 17) the bundles are far out and may have been entering the leaf-base; the tissue, however, is damaged and one of the two strands ($v.b.^1$) lies in the débris. The signs of division in each bundle are less marked here than in the other cases mentioned.

So far as the available data show, the behaviour of the leaf-trace in the α form of stem seems to have been much the same as in the "*cylindricum*" form, already described, the trace consisting of two large strands which pass out without separating very widely, and do not complete their subdivision till after they have entered the leaf-base; in both cases more than one trace may be met with in the transverse section.

A word may be added about the branching, already described and figured in the joint memoir *. The branch appears in three successive sections of specimen 2 †. In the lowest section the continuity between branch and stem is more complete than in that figured (the middle one); the stele of the branch is smaller, and its zone of secondary wood thicker. At this level there is a little secondary wood on the main stele also—a small arc 620 μ broad and about 6 cells thick on the side towards the branch. It dies out higher up the stem. In the third section (W. 1885 H; above that figured) the branch is free from the stem, but still shows no leaf-traces of its own; it is, however, not quite complete. At this level, the secondary wood of the branch has all

* Williamson & Scott, 1895, p. 753, pl. 26. fig. 21.

† W. 1885 HH, 1915 N, 1885 H.

but died out, and the structure is that of an ordinary stem of the α form. The branch is very similar to the smaller stem (2 *a*) appearing in the same section, and it is quite likely that the latter may represent another branch of the same main axis. It is evident that secondary growth started at the base of the branch, where it also slightly affected the parent stem.

As regards the nature of the α form of stem, there is no doubt that it has a distinctive anatomical habit, and we cannot wonder that Williamson at first inclined to make it a separate species. Even allowing for the better preservation of the cortex in the younger stems, the difference can hardly be reduced to one of age; I have seen no β stems that can naturally be interpreted as the older stages of α stems. The youngest β specimens, which ought to come nearest to the α form, do not possess the powerfully constructed cortex which characterizes the latter.

Not much stress can be laid on the fact that an α specimen is the only one that shows branching. The specimens after all are few, and we must remember that it was a long time before branching stems of *Lyginopteris oldhamia* were found, common as the plant is. In *Heterangium* generally, branching must have been extremely rare; whether it was so in the Dulesgate species we cannot tell.

The various forms of stem described under *H. Lomaxii* all occur in a single coal-ball; it appears that none of them have been found in any other block. It seems almost infinitely improbable that two or more distinct species of the same genus, each of the extremest rarity, should happen to be associated in one unique nodule; the presumption is overpoweringly strong that all the specimens belong to one and the same species. The α form is the most distinct in appearance, but I do not doubt that Williamson's later view was essentially correct and that it represents a younger stage of growth of one of the other Dulesgate forms of stem, though not perhaps of a form exactly identical with any of those which we possess in a more advanced state.

Whether the differences among the specimens of *H. Lomaxii* are due to variability in homologous stems, or to the occurrence of multiform stems in the same plant, cannot be decided. The latter seems more probable, but we have no proof, for in the only case where a stem has been observed to branch the branch merely repeats the characters of the parent axis.

Petioles.

The evidence we have collected so far only proves that in *H. Lomaxii* two bundles, each showing signs of division, entered the leaf-base; we do not yet know how many distinct strands were present in the petiole. The material contains a few specimens of petioles, though none are well preserved. As they are associated with various forms of *H. Lomaxii* stem, it is impossible to tell to what particular form they belonged; from their size, they were probably borne on the larger stems. Three of these petioles are tolerably clear—a section of one of them is shown in Pl. 4. fig. 18. In other sections of the same

petiole the sclerotic nests appear, and the dense hypoderma is also that of a *Heterangium* *. The tissues are much permeated by roots and rootlets, but the vascular bundles belonging to the petiole are easily recognized in all the sections. There are four large bundles, two widely separated in the section figured, and two close together. The two more median bundles are clearly dividing; where the structure is well enough preserved, the bundle is evidently mesarch with little centrifugal wood, and is thus completely of the *Heterangium Lomaxii* type. This petiole is much compressed, and measures where complete about 6 × 1 mm. There is no doubt that it belongs to the *Heterangium*, and it thus proves that the bundles completed their division into four after entering the petiole, and even initiated further subdivision.

Another larger and much crushed petiole † (7·5 × 1 mm. in diameter) shows, in the best section, four bundles, two of which are dividing. A third specimen ‡, of about the same size (6 × 1·5 mm.), contains four large bundles, quite separate, but not obviously dividing further. All these show the *Heterangium* characters unmistakably. It is a pity that we have no petiole in continuity with the stem, but the evidence is enough to show that in *H. Lomaxii*, as in *H. shorense* and *H. tiliæoides*, the petiole was polydesmic, the minimum number of bundles being four.

It is evident that the three species of *Heterangium* which have now been described were nearly allied; they agree among themselves in having polydesmic petioles, and are the only species recorded in which this character has been observed, though it may be found to extend to others.

The forms now grouped under *H. Lomaxii* appear, for reasons already given, to constitute a single species, distinct though not very different, from *H. shorense* and *H. tiliæoides*. The specific characters may be summed up as follows:—

Heterangium Lomaxii, Will. in litt.

Stem from about 5 or 6 mm. to about 13 mm. in diameter.

Primary wood consisting of somewhat irregular groups of tracheides, with parenchyma between the groups.

Tracheides without any spiral bands between the pits.

Peripheral xylem-strands and leaf-trace bundles mesarch with little centrifugal wood.

Secondary phloem sometimes well developed, but phloem-rays not much dilated.

Pericycle generally of moderate breadth, but much enlarged where leaf-traces or roots pass out.

* This petiole occurs in five sections of the specimen 2 (α form) series, namely W. 1915 N, 1885 H, 1915 O; S. 236 and R. 642.

† Occurring in the sections W. 1915, 1915 B, 1915 A.

‡ In the University College slide, N. 3.

Sclerotic tissue present both in pericycle and cortex ; the sclerotic nests in the cortex forming massive blocks, sometimes (in stems of the α form) developed to a remarkable extent.

Leaf-trace consisting of two bundles where it leaves the stele, the constituent bundles often very widely separated in the cortex, when adventitious roots pass out between them. Trace-bundles without secondary wood of their own. The double trace beginning to divide into four as it enters the leaf-base. Four bundles, sometimes further subdividing, in the petiole.

Number of traces in the transverse section, one only in some specimens, two or perhaps more in others. Traces traversing the stem for a long distance before passing out.

Stem observed to branch, the secondary growth in this case starting at the base of the branch.

Details of cortical structure and of arrangement of leaf-traces varying in different forms of stem.

Locality. Dulesgate, Lancashire : Lower Coal Measures.

All the specimens, apparently from a single nodule, discovered by Mr. James Lomax about 1890.

It may be mentioned that the present re-investigation has thrown no new light on the structure of the root in *Heterangium Lomaxii*. That question remains now as it was in 1895 *.

HETERANGIUM MINIMUM, sp. nov.

A single specimen of this small stem occurs in a block from Dulesgate, of which sections were received from Mr. James Lomax in February, 1903 †. Though the locality is the same as that of *H. Lomaxii*, the material is quite different, and contains different plants. There is therefore no presumption of specific identity between this form and those referred to *H. Lomaxii*. The characters indicate that it is distinct.

The dimensions of the stem, about 2·9 mm. by 1·7 mm. in its somewhat crushed condition, are unusually small for a *Heterangium*. The best section is shown in Pl. **4**. fig. 19. The wood, including a few secondary layers, measures about 1·6 × 1 mm. The primary wood consists mainly of tracheides, with comparatively little conjunctive parenchyma. The peripheral xylem-strands are not sharply defined, and the principal rays of the secondary wood by no means conspicuous. In these respects the specimen recalls *H. Grievii* rather than the Coal-Measure species. The tracheides of the metaxylem are decidedly large for the size of the stem, often exceeding 150 μ in diameter. The structure of the peripheral strands is mesarch, with one or two layers of centrifugal primary wood. The secondary wood, which reaches a maximum

* Williamson & Scott, 1895, pp. 758, 764. The evidence there brought forward relates entirely to the Dulesgate species, *H. Lomaxii*.

† The sections are S. 1801, 1803, 1804, 1805, and 1813, all transverse.

thickness of about seven elements, is small-celled, as usual, the tracheides seldom exceeding 36 μ in diameter. The phloem is destroyed ; the pericycle tolerably preserved in places. No sclerotic nests have been detected either in the pericycle or the cortex—one would not expect a strong mechanical construction in so small a stem. The cortex is parenchymatous, with a rather feeble *Sparganum* zone on the outside.

In the section figured a leaf-trace is seen in the pericycle. It is a single strand, though somewhat lobed ; other sections show that the trace divided into two strands further out on its course, but they have not been seen to diverge. In one section (S. 1805) a second trace is seen, just separating from the wood, as a single strand, with two protoxylem groups.

It thus appears that *Heterangium minimum* differs from all other forms described in this paper in having a leaf-trace consisting of a single bundle where it starts from the stele. In this point it agrees with *H. Grievii*, but differs in the fact that the trace divided into two in the cortex. Of course, it cannot be strictly proved that *H. minimum* may not have been a minute twig of some other species ; there is, however, nothing to indicate that this was the case, and on present evidence the plant must be regarded as distinct. The specific characters may run as follows :—

Heterangium minimum, sp. nov.

Stem minute, under 3 mm. in diameter.

Primary wood consisting chiefly of tracheides with a few parenchymatous bands. Peripheral xylem-strands not well defined ; mesarch, with a layer or two of centrifugal wood.

Sclerotic tissue apparently absent from both pericycle and cortex. Leaf-trace a single bundle where it leaves the stele, dividing into two in the cortex.

Locality. Dulesgate, Lancashire : Lower Coal Measures.

Found by Mr. James Lomax in 1903.

A New Subgenus.

If for the moment we leave *Heterangium minimum* out of account, we find that the other three British Coal-Measure species of the genus, while differing only in trivial points, agree in the following characters : the distinctness of the peripheral xylem-strands, and consequently of the principal medullary rays ; the tendency towards exarchy in the primary xylem-strands, the centrifugal primary wood being little developed ; the compound leaf-traces, double on starting from the stele, quadruple or more on entering the petiole.

The first of these characters may reasonably be considered as an advance on the structure of the *H. Grievii* type, in which the peripheral strands of the stele are not sharply delimited. Their greater distinctness is a departure from the pure protostelic structure, and indicates a progressive downward differentiation of the leaf-trace system.

On the other hand, we cannot be certain that the exarch tendency of the primary xylem-strands marks an advance, for we find both types of structure in species of similar age, as will be shown below. In the Coal-Measure forms, the centrifugal xylem, though little developed, is sharply differentiated and obviously primary; indeed, from the nature of the tracheides (spiral or scalariform) it would appear that the centrifugal part of the strand was the first to be formed after the protoxylem, with which it is in direct connection, as in *H. Grievii* and *Lyginopteris*, a point on which Chodat has laid stress * (Chodat, 1908, p. 13).

In the double leaf-trace and polydesmic petiole, the Coal-Measure species undoubtedly show a more complex organization than has hitherto been described in *Heterangium*, or even in *Lyginopteris*, for we have here to do with a trace which is *double at its origin*, not as in *Lyginopteris* with one that merely divides as it passes out. The further subdivision of the trace, giving rise to four or more bundles in the petiole, gives a most distinct character to the species in question; the creation of a new genus for them might be suggested. There are, however, objections to this course, and I prefer to be content with proposing a provisional subgenus, which may be named POLYANGIUM †, and may best be characterized simply by the leaf-trace being double on starting from the stele, and dividing into four or more strands in the petiole.

The proposed new subgenus will, of course, include the three species *H. shorense*, *H. tiliæoides*, and *H. Lomaxii*, with the probable addition of others. *H. minimum*, on the other hand, will fall under the other subgenus, which may be called EU-HETERANGIUM, characterized by the single leaf-trace given off from the stele remaining single or dividing into two strands only on its passage outwards. I have not thought it desirable to introduce the other characters (distinctness of xylem-strands and tendency to exarchy) into the diagnosis of the provisional subgenus, as we have no reason to assume that they are consistently correlated with the polydesmic condition.

A rapid comparative survey of the other species of the genus and of some related groups will serve to make the position clear.

COMPARATIVE CONSIDERATIONS.

Corda's original species *Heterangium paradoxum* ‡ was founded on fragmentary material, which practically shows nothing beyond the structure of the metaxylem. Kubart (1911, p. 9, Taf. i. fig. 3), who examined smaller

* Prof. Chodat uses the position of the protoxylem as an argument against the homology of the bundle in Lyginopterideæ with that in Cycadaceæ, a point with which we are not concerned in the present paper.

† Intended to suggest a *polydesmic Heterangium*.

‡ First published in 1845. The reference is to the edition of 1867: 'Flora der Vorwelt,' p. 22, pl. xvi.

specimens from the same locality, figures a complete stele, but no details are given, and beyond confirming the general agreement with other species referred to the genus, there is nothing to be said. The plant is apparently of Middle Coal-Measure age.

Williamson's Lower Carboniferous species *H. Grievii* is too well known to need any discussion here. It may, however, be convenient shortly to recapitulate the principal characters:

Peripheral xylem-strands not sharply delimited.

Primary centrifugal wood of the bundles well developed.

"Secretory sacs" scarce or absent.

Sclerotic plates (in the form of thin discs) present in the cortex, but not in the pericycle.

Leaf-trace single and a single bundle in the petiole.

Leaf-bases large and decurrent.

Foliage probably that of *Sphenopteris elegans*.

This species is the type of the subgenus *Eu-heterangium*. I am not aware that the structure of any other Lower Carboniferous species has been described *.

In the meantime, Renault (1869, p. 177) had described two species, under the names *Lycopodium punctatum*, Ren., and *Lycopodium Renaultii*, Brongn., which have proved to belong to the genus *Heterangium*. These fossils came from the Upper Coal Measures of Autun. The reference to *Lycopodium* involved a misinterpretation of the structure of the specimens †, and it is more profitable to refer to Renault's later description (Renault, 1896, p. 253), written after he had recognized the true nature of the plants. The only figures are those in the earlier paper. Both species are represented by small stems, 5·5–6 mm. in diameter. *H. punctatum* has a certain amount of secondary wood and bast, which are absent in *H. Renaultii*; it is possible, as Renault pointed out, that the latter may merely be a younger condition of the former (Renault, 1896, p. 256). I examined the original preparations at Paris in 1905, but at that time my attention was not directed to the points which now seem most critical. *H. punctatum*, especially, bears a close resemblance to our *H. tiliæoides*; it has, for example, large medullary rays, which are dilated in the phloem-zone (Renault, 1869, pl. 12. fig. 3; pl. 13. fig. 4). The leaf-traces are said by Renault (1896, p. 254) to pass out opposite the rays, a statement which is scarcely confirmed by the figure (1869, pl. 12. fig. 1). Renault gives no definite information as to the position of the protoxylem, merely stating that the attenuated peripheral extremities of the vascular groups are occupied by rayed tracheides and spiral elements (trachées).

* Prof. T. Johnson's species, *H. hibernicum*, is based on external characters only (Johnson, 1912).

† *Cf.* Williamson & Scott, 1895, p. 771.

In describing *H. Renaultii*, he makes the important remark that "on one side of the woody cylinder we notice two bundles which are separating from the axis, and in the parenchymatous part of the cortex two others which have already quitted it for a certain time" (1896, p. 255). It thus appears that this species gave off its leaf-trace bundles in pairs. He also observed indications of "dichotomy" in the bundles. I have little doubt that both forms may be referred to the subgenus *Polyangium*, but a re-investigation is required.

Another Autun species, *H. Duchartrei*, Ren., was originally described under the name of *Poroxylon Duchartrei* (Renault, 1879, p. 276, pl. 14. figs. 4–8); it was excluded from that genus in 1886 (Bertrand & Renault, 1886, p. 245), and appears as a *Heterangium* in the 'Flore d'Autun et d'Épinac' (Renault, 1896, p. 251, pl. 65. figs. 1, 2). The stem (6·5 mm. in diameter) has very much the characters of *H. tiliæoides*, but little beyond the wood is preserved. The principal rays are conspicuous, dividing up the secondary zone into 15 sectors (Renault, 1896, pl. 65. figs. 1, 2) *. Here, again, the groups of spiral and scalariform tracheides are described as lying at the periphery of the primary wood. Two bundles, widely separated, but on the same side of the stem, are seen in the cortex; there can be little doubt but that they both belonged to the same leaf-trace. It appears, then, that this form also may be included under the provisional subgenus *Polyangium*. Renault calls attention (1896, p. 254) to the similarity between *H. Duchartrei* and *H. punctatum*; it is possible that all the three forms just described may eventually be reduced to one species.

On the other hand, a fourth Autun form, *H. bibractense*, Ren. (Renault, 1896, p. 252, pl. 65. figs. 3–6), seems to be quite distinct. It is remarkable for the small size of the primary wood (1–1·5 mm. diameter) and the great thickness of the secondary tissues †. Parts of the phloem and the cork are preserved. There are large principal rays as in the preceding species. Nothing is known of the leaf-traces. No other *Heterangium* has been found in such an advanced state of growth.

It will be noticed that all the Autun specimens, so far as their structure is known, agree better with the British Coal-Measure forms of the *Polyangium* type than with the Lower Carboniferous species *H. Grievii*. This is natural, considering their age, which is considerably later even than that of our Coal-Measure forms.

We have now briefly to consider the very interesting series of species of *Heterangium* recently described by Dr. Kubart from the Ostrau beds of Upper Silesia (Kubart, 1908, 1911, 1914). At present only preliminary accounts have been published, so the data for a full comparison with our own

* The figures of the 1896 memoir appear to be much more exact than those of 1879.

† Renault gives the thickness of the wood as 5·5 mm. I found it to reach nearly a centimetre in places.

species are not yet available *. The Ostrau specimens, which are admirably preserved, are very interesting from their age, which is somewhat earlier than that of our Lower Coal Measures, corresponding, according to Dr. Kubart, to the upper part of our Millstone Grit. The great point which his investigation has brought out is the existence of transitional forms between the genera *Heterangium* and *Lyginopteris*, confirming the close affinity between them, as maintained by Williamson and the present writer. Here, however, our point of view is somewhat different; we are interested rather in the comparison between Dr. Kubart's species and the British Coal-Measure Heterangiums.

Five species of *Heterangium* from Ostrau are described—all appear to be new. The simplest structure is shown by *H. Sturii*, where there is practically no differentiation in the stele between metaxylem and primary bundles (Kubart, 1914, p. 3, Taf. 2. fig. 3); the latter only become delimited when they begin to pass out as leaf-traces. The protoxylem, however, is nearly exarch. In the figure, five large leaf-traces are shown leaving the stele: all are single and no sign of division is to be observed; evidently then, each leaf received a single bundle, and *H. Sturii* is a typical representative of the subgenus *Eu-heterangium*. It will be noticed that in this case a tendency to exarchy co-exists with an undifferentiated stele, contrary to what we found in the British Coal-Measure species.

H. alatum † has more or less well-defined peripheral primary bundles; their structure is typically mesarch, with well-developed centrifugal xylem. The leaf-traces are numerous (I counted 10 in the transverse section) and one bundle passed out into each leaf. A number of small winged petioles surrounded the stem, and are sometimes found still in connection with it. The secondary wood, when formed, is described as a perfectly continuous ring. *H. alatum* is thus an obvious member of the *Eu-heterangium* subgenus—the numerous small petioles give it, however, a very different character from *H. Grievii*.

H. polystichum is a somewhat similar species ‡, with fairly distinct peripheral xylem-strands, which, like the leaf-trace bundles, are "centrally mesarch," *i.e.* with the protoxylem deeply imbedded. A single bundle leaves the stele for each trace; the traces are very numerous, 13 appearing in the transverse section. The trace, on entering the leaf-base, may possibly have divided into two. The species evidently falls under the subgenus *Eu-heterangium* as defined above. It is distinguished from *H. alatum* chiefly by a difference in the petioles.

* Through Dr. Kubart's kindness, I have had an opportunity of examining sections of several of his species.

† Kubart, 1914, p. 2, Taf. 2. figs. 1, 2.

‡ Kubart, 1911, p. 11, Taf. 1. fig. 4; 1914, p. 4.

H. Schusteri (Kubart, 1908, fig. 3; 1911, p. 11; 1914, p. 3) is intermediate, as regards the stelar structure, between *H. Sturii* and *H. alatum*; the peripheral xylem-strands are only slightly differentiated. Nothing is said about the position of the protoxylem; from the figure it appears to lie rather far out, approaching *H. Sturii* in this respect. The figure shows three leaf-traces very clearly, one just starting as a single strand, another, in the pericycle, somewhat constricted, and a third, also in the pericycle, just divided into two. The plant thus falls under *Eu-heterangium*, resembling our *H. minimum* in the division of the originally single trace.

H. Andrei (Kubart, 1914, p. 4, Taf. 2. fig. 4) is the most interesting of the five species, as it shows a transition towards *Lyginopteris*. The transverse section of the large stem shows quite the anatomical habit of a *Lyginopteris*; the primary tracheides, however, extend to the centre of the pith, where they are scattered and intermixed with much parenchyma. The peripheral strands of the xylem are quite distinct and few in number, as in *Lyginopteris*; the leaf-trace starts from the stele as a single bundle, which divides into two, much as in *Lyginopteris oldhamia*. In sections lent me by Dr. Kubart, which I have no doubt were of the species subsequently named by him *H. Andrei*, I found in connection with the stem a leaf-base containing four bundles, as well as detached petioles with the same structure *. It appears, then, that *H. Andrei* unites the characters of our two subgenera, a single trace leaving the stele and ultimately dividing into four in the leaf-base. This fact, if confirmed, would be a fatal objection to the establishment of a new genus for the polydesmic forms, but our provisional subgenera may still serve a useful purpose. Possibly Dr. Kubart may eventually suggest a third subgenus for the Lyginopteroid species of *Heterangium*. We are not here concerned with Dr. Kubart's new species of *Lyginopteris*, but may mention that *L. heterangioides* (Kubart, 1914, p. 4, Taf. 2. fig. 5) is a typical member of that genus, except for the constant presence of a few tracheides about the middle of the pith, an evident vestige of the metaxylem of *Heterangium*, already becoming reduced in *H. Andrei*. A species from the coal-field of the Ruhr (Westphalia), named *H. intermedium* by Kubart (1914, p. 6), is described as forming a link between *Heterangium Andrei* and *Lyginopteris heterangioides*: we have, in fact, as the discoverer points out, a continuous series leading gradually from the protostele typical of *Heterangium* to the siphonostele typical of *Lyginopteris*.

To return to our more immediate subject: the result of our survey is to show that the older species of *Heterangium* tend, on the whole, to belong to the simpler *Eu-heterangium* type, while the later species for the most part show the more complex structure which characterizes the proposed subgenus *Polyangium*.

* I noticed long, stalked glands on both stem and petiole—a very *Lyginopteris*-like feature.

A few words may now be added about other genera which present points of comparison with *Heterangium*. The nearest of these is doubtless *Rhetinangium*, founded by Dr. Gordon on the species *R. Arberi*, which he discovered in the Pettycur beds of the Calciferous Sandstone Series (Gordon, 1912). The plant is thus of Lower Carboniferous age and contemporary with *Heterangium Grievii*. The structure is protostelic, and the general appearance of the transverse section suggests a rather large stem of *Heterangium*. The new genus, however, differs from *Heterangium* in important characters: there are no sclerotic plates in the cortex or pericycle; the primary xylem-strands are exarch, not mesarch, and the leaf-trace is a complex corrugated body with numerous external protoxylem groups. Minor peculiarities are the great development of secretory sacs and cells (also present in some species of *Heterangium*) and the enormous enlargement of the leaf-base, which almost equals the whole stem in thickness. The *Sparganum*, or more strictly *Dictyoxylon*, outer cortex is very finely developed, as in *Medullosa*. The exarch character of the xylem-strands is important; we have no evidence that true exarchy occurs in *Heterangium*, though, as we have seen, there are considerable variations in the degree of mesarchy. On the other hand, the structure of the metaxylem seems to me to be altogether that of a *Heterangium*, of the type, like *H. shorense* or *H. tiliæoides*, where the tracheides are in definite packets, separated by a reticulum of parenchyma. The secondary wood is of the ordinary *Heterangium* kind, with somewhat large rays opposite the spaces between the peripheral xylem-strands.

But the most interesting point for our comparison is the leaf-trace, a remarkable and unique structure. It embraces several of the peripheral xylem-strands, all passing out together and all in connection laterally with each other. The connection being on the adaxial side, the leaf-trace consists of a number of fused U-shaped bodies, concave outwards. The protoxylem-groups, on the extreme outside, are numerous—six or more in number.

The massive trace may remind us for a moment of a meristele of *Sutcliffia* (Scott, 1906), but is really quite different, for it never breaks up or divides in any way, but passes out unaltered into the petiole. It is a complex but never a multiple leaf-trace. *Rhetinangium* thus also differs fundamentally from our polydesmic Heterangiums, where the trace from its origin consists of two distinct and simple bundles, which divide further on their outward course to form more bundles of like nature. *Rhetinangium* is a most interesting parallel development, doubly interesting from its antiquity, but it has, in my opinion, no special affinity with the polydesmic species of *Heterangium*.

Prof. Seward's genus *Megaloxylon* (Seward, 1899) is more remote from *Heterangium*. The large stem agrees with *Rhetinangium* in the exarch structure and in the presence of several protoxylem-groups on the abaxial side of the leaf-trace, but is peculiar in the character of the metaxylem, which consists for the most part of short wide tracheides, apparently adapted

for water-storage. As only the wood is known, we have no information as to the outward course of the leaf-traces. On the existing evidence, there is nothing to connect the genus with the polydesmic species of *Heterangium*, though *Megaloxylon* appears to represent, in a different direction, an advance on the original protostelic type of structure.

Polydesmy is common enough among plants grouped under Pteridosperms or Cycadofilices, but the only families which seem near enough to *Heterangium* to deserve mention here are the Medulloseæ and the Calamopityeæ.

A simple Medullosean stem, such as that of *Medullosa anglica*, has been described as essentially a polystelic *Heterangium*. Each stele, in fact, repeats the characters of the *Heterangium* monostele; the position of the protoxylem-groups is mesarch, but approaching exarchy, as in our polydesmic Heterangiums. Several distinct bundles are given off from the stele to form the trace of a single leaf and they divide up freely on their passage outwards (Scott, 1899, p. 194; 1914; de Fraine, 1914). In all these points there is a clear analogy with the plants which form the subject of this paper, the polydesmy, of course, going much further in *Medullosa* than in any species of *Heterangium*.

Sutcliffia, though not strictly polystelic, otherwise differs from *Heterangium* more widely than does a *Medullosa* of the *anglica* type. The stele is exarch, the emission of leaf-traces takes place through the intermediation of bulky meristeles, and the trace-bundles are concentric throughout (Scott, 1906; de Fraine, 1912). The polydesmic Heterangiums no doubt show some slight approach towards certain characters of the Medulloseæ, but not enough to justify one in supposing that they are on the line of descent of the latter family.

A comparison with the Calamopityeæ is interesting. These are monostelic plants which until recently have been assumed to have had a true pith, surrounded by a ring of primary mesarch xylem-strands, the stem-structure thus presenting a close analogy with that of *Lyginopteris*. In a joint paper on Kentucky fossil plants, of Lower Carboniferous age, Prof. Jeffrey and I have, however, shown that the structure in the species *Calamopitys americana* was essentially protostelic, the "mixed pith" containing a varying proportion of tracheides among the parenchyma (Scott & Jeffrey, 1914, pp. 318, 326). There is reason to suspect that the same may be true of the Thuringian species, *C. annularis* (Unger). This brings the species in question nearer to the *Heterangium* type of structure. The petiole (*Kalymma*) has long been known to be polydesmic; our work on *C. americana* showed that the leaf-trace, single at its origin, almost immediately divides into two strands *, further subdividing in the cortex. In *C. Saturni*, Unger, previously

* Since the paper by Prof. Jeffrey and myself was published, I have obtained even more convincing evidence of the early division of the trace.

investigated by Count Solms-Laubach *, the first division takes place further out. These plants thus present interesting analogies with the polydesmic species of *Heterangium*, though never, of course, any exact agreement. I think this is really the most fertile comparison we can make, and that the polydesmic petioles of our Coal-Measure Heterangiums may well be described as showing an approach to the *Kalymma* (*Calamopitys*) structure †. Even here there can be no question of filiation. The species of *Calamopitys* are probably older than any known *Heterangium*, and certainly much older than any which have been found to have polydesmic petioles.

While, then, *Heterangium* is directly connected with *Lyginopteris* through the intermediate species discovered by Dr. Kubart, we have no evidence that the polydesmic forms indicate a transition to any other genus. They present interesting analogies with the Medulloseæ and Calamopityeæ, and show that there was more in common between these groups and the Lyginopterideæ than has hitherto been supposed. But we have no sufficient grounds for assuming any direct evolutionary connection.

Summary.

The characters of the various species described have been given above (pp. 65, 73, 89, 91). The more general results may be summed up as follows :—

1. The three British Coal-Measure species, *Heterangium shorense*, *H. tiliæoides*, and *H. Lomaxii*, agree in their more important characters and only differ in details. The fourth species, *H. minimum*, is of a different type.

2. The three species first named may conveniently be grouped in a provisional subgenus, *Polyangium*, characterized by the leaf-trace, starting from the stele as two distinct bundles, which further divide on their outward course, the number of bundles in the petiole ranging from four to eight.

3. In addition to the polydesmic structure, these three species further agree in the sharp delimitation of the primary peripheral xylem-strands, with the consequent differentiation of large interfascicular principal rays, and in the approach to exarchy in the peripheral strands and leaf-trace bundles, the primary centrifugal xylem being comparatively little developed.

4. It is probable that, besides *H. shorense*, *H. tiliæoides*, and *H. Lomaxii*, the four species described by Renault, from the Upper Coal Measures of

* Solms-Laubach, 1896, p. 67.

† There is no reason to believe that the protostelic structure of the stem existed in *Calamopitys Saturni*, Unger, or in the two species (*C. fascicularis*, Scott, and *C. Beinertiana* (Goeppert)) separated by Dr. Zalessky, under the name *Eristophyton* (Zalessky, 1911, p. 27). I am not sure that I agree with Dr. Zalessky in his proposed division of the genus, *C. Saturni* seems to have in some respects more in common with my *C. fascicularis* than with *C. annularis* or *C. americana*. The whole question is discussed in a forthcoming paper on the genus.

Autun (*H. punctatum* *, *H. Renaultii* *, *H. Duchartrei* *, and *H. bibractense*) are referable to the subgenus *Polyangium*.

5. The Lower Carboniferous species *H. Grievii* may be taken as the type of another subgenus, *Eu-heterangium*, characterized by the leaf-trace consisting of a single bundle only, where it leaves the stele, this bundle either remaining undivided on its outward course or dividing into two strands only. One Dulesgate species, *H. minimum*, falls under this subgenus, as do also four of the Ostrau species described by Dr. Kubart, namely *H. alatum*, *H. polystichum*, *H. Schusteri*, and *H. Sturii*. The peripheral xylem-strands are, on the whole, less distinct in *Eu-heterangium* than in *Polyangium*, but the degree of their differentiation varies in the different species. The xylem-strands may either be "centrally mesarch" or show a tendency towards exarchy. A third subgenus may be required for the Lyginopteroid species, such as *H. Andrei*, discovered by Dr. Kubart.

6. The polydesmic species of *Heterangium* (*Polyangium*) show an interesting analogy with Medulloseæ and with the protostelic Calamopityeæ. There is, however, no sufficient evidence of any direct phylogenetic relation to either group. With *Rhetinangium* there is no special affinity, for, while this genus appears to have much in common with *Heterangium*, its leaf-trace is complex and not multiple, thus presenting only a remote analogy with that of the polydesmic Heterangiums. *Megaloxylon* is altogether more remote.

The generic characters given on p. 59 of this paper can now be made more precise as regards the nature of the leaf-trace in different subdivisions of the genus as stated in the Summary above, under the headings 2 and 5. It also appears that in such species as *H. alatum*, Kubart, and *H. polystichum*, Kubart, the leaves were small and probably very different from the foliage of *Sphenopteris elegans*, attributed with good reason to *H. Grievii*.

I am much indebted to my friends Prof. F. W. Oliver, F.R.S., and Prof. F. E. Weiss, F.R.S., for the loan of slides in the University College, London, and the Manchester Museum Collections. Without the opportunity of consulting these preparations, in addition to those in the Williamson Collection and in my own, it would have been impossible to deal at all adequately with the subject.

The majority of the sections described were cut by Mr. Lomax, to whom the discovery of *H. shorense* and of the Dulesgate species is due.

The photographic illustrations are the work of Mr. W. Tams, while the drawings were made by Mr. G. T. Gwilliam, to both of whom my best thanks are due for their valuable aid.

* These three may perhaps be forms of the same species.

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EXPLANATION OF THE PLATES.

PLATES 1 & 2.

From Photographs by Mr. W. Tams. They require to be examined with a lens in most cases.

PLATE 1.

Phot. 1. *Heterangium shorense.* General transverse section of stem. *Cf.* Plate 3. fig. 1.
A. Three bundles in the leaf-base (one is missing).
D. Double leaf-trace still attached to the stelar wood.
× about 5. Slide S. 2793.

Photographs 2–8. *Heterangium tiliæoides.*

Phot. 2. General transverse section, from specimen 1. Note the well-preserved cortex.

T. 1. Double leaf-trace, in connection with stelar wood.

T. 2. Next outer trace; only one bundle shown.

T. 3. One pair of bundles of outermost trace. T. 3^1. The other pair, damaged.

× about 6. Slide, Manchester, R. 632.

Phot. 3. General transverse section, from specimen 2.

T. 1. Double trace, just leaving stele.

T. 2. Bundles of a second trace, far out in pericycle.

l.b., outer limit of large leaf-base in connection with stem.

× about 6. Slide S. 237.

Phot. 4. Leaf-base from Phot. 3, enlarged.

v.b., one pair of bundles in the leaf-base; *v.b.*^{1}, the other pair, damaged; C, outer cortex of leaf-base; *sc.*, sclerenchyma delimiting leaf-base laterally; *p.c.*, portions of pericycle of stem.

× about 11. Slide S. 237.

Phot. 5. Part of another transverse section of specimen 2, showing a leaf-trace, consisting of two large bundles, starting from the stele.

x., primary; *x.*^{2}, secondary xylem of stele; *ph.*^{2}, secondary phloem of leaf-trace; *p.c.*, pericycle.

× about 40. Slide, Manchester, R. 654.

Phot. 6. General transverse section from specimen 3.

r.x., root-base, connected with the xylem of the stem; *r.*, free root.

T. 2. Leaf-trace in pericycle.

× about 6. Slide, Manchester, R. 658.

Phot. 7. From the section next below the last.

r., root, imbedded in the cortex of the stem.

× about 8. Slide, Manchester, Q. 60.

Phot. 8. General transverse section from specimen 4. Note that everything beyond the pericycle is lost.

T. 1. Inner trace, of two bundles, just leaving the stele.

T. 2. Outer trace, of two widely separated bundles, passing out from the pericycle. *Cf.* Pl. **4**. fig. 12.

× about 6. Slide S. 1323.

PLATE 2.

Photographs 9–15. *Heterangium Lomaxii.*

Phot. 9. Form *β*. General transverse section from specimen 1. Lowest section.

v.b., the two widely separated bundles of the leaf-trace.

× $6\frac{1}{2}$. Slide S. 447.

Phot. 10. Peripheral xylem-strands from Phot. 9, enlarged.

px., protoxylem of one of the strands; *x.*, primary; *x.*^{2}, secondary xylem.

× about 40. Slide S. 447.

Phot. 11. Form *β*. General transverse section from specimen 1. Uppermost section.

v.b., the two bundles of the leaf-trace, here much more widely separated than in Phot. 9; *r.*, adventitious root passing out between them.

× about 8. Slide W. 1915 A.

Phot. 12. Form *β*. General transverse section from specimen 6.

T. 1. Double leaf-trace in the outer part of the pericycle.

T. 2. Another double trace, just entering the cortex.

× about 18. Slide, Univ. Coll., N. 3.

Phot. 13. Form *β*. General transverse section from specimen 5.

ph.[2], secondary phloem; *hy.*, thin-walled hypoderma.

T. 1. Inner leaf-trace, of two separate bundles, just leaving the stelar wood.

T. 2. Outer trace, two minute bundles in pericycle.

× about 10. Slide S. 625.

Phot. 14. Form "*cylindricum.*" General transverse section.

T. 1. Inner leaf-trace, consisting of two strands, just starting from the stelar wood.

T. 2. Outer trace of two double bundles in the cortex.

× about 10. Slide, Univ. Coll., N.

Phot. 15. Form *α*. Part of a transverse section from specimen 1, showing a leaf-trace, consisting of two double bundles, *v.b.* *x*, xylem of stele.

× about 35. Slide, Manchester, Q. 10.

Plates 3 & 4.

From drawings by Mr. G. T. Gwilliam.

Plate 3.

Figs. 1–7. *Heterangium shorense.*

Fig. 1. Transverse section of stem, showing stele with pericycle, and cortex with sclerotic masses and *Sparganum* hypoderma.

A., A., leaf-base with three bundles preserved (*cf.* fig. 2); B., B., next inner trace, with four bundles in pairs; C., C., trace further in, consisting of two double bundles (*cf.* fig. 6); D., innermost trace of two bundles.

× 7. Slide S. 2791.

Fig. 2. Transverse section of leaf-base attached to stem. The four bundles (*v.b.*) in the leaf-base are evident.

sc., *sc.*, sclerenchyma delimiting leaf-base at the sides; *s.p.*, sclerotic plate.

× 6. Slide S. 2787.

Fig. 3. Detached petiole, containing eight bundles in four pairs.

s p., sclerotic plate.

× 6. Slide S. 2787.

Fig. 4. Leaf-trace consisting of two bundles (*v.b.*), starting from the stele.

st., stelar wood.

× 26. Slide S. 2794.

Fig. 5. Part of primary xylem, showing three peripheral strands.

p.x., protoxylem of one of the strands.

× 26. Slide S. 2792.

Fig. 6. Part of stele and half a leaf-trace.

x.[2], secondary xylem beginning to form on stele; *pc.*, pericycle; *v.b.*, double bundle, forming one-half of the trace C., C., shown in fig. 1.

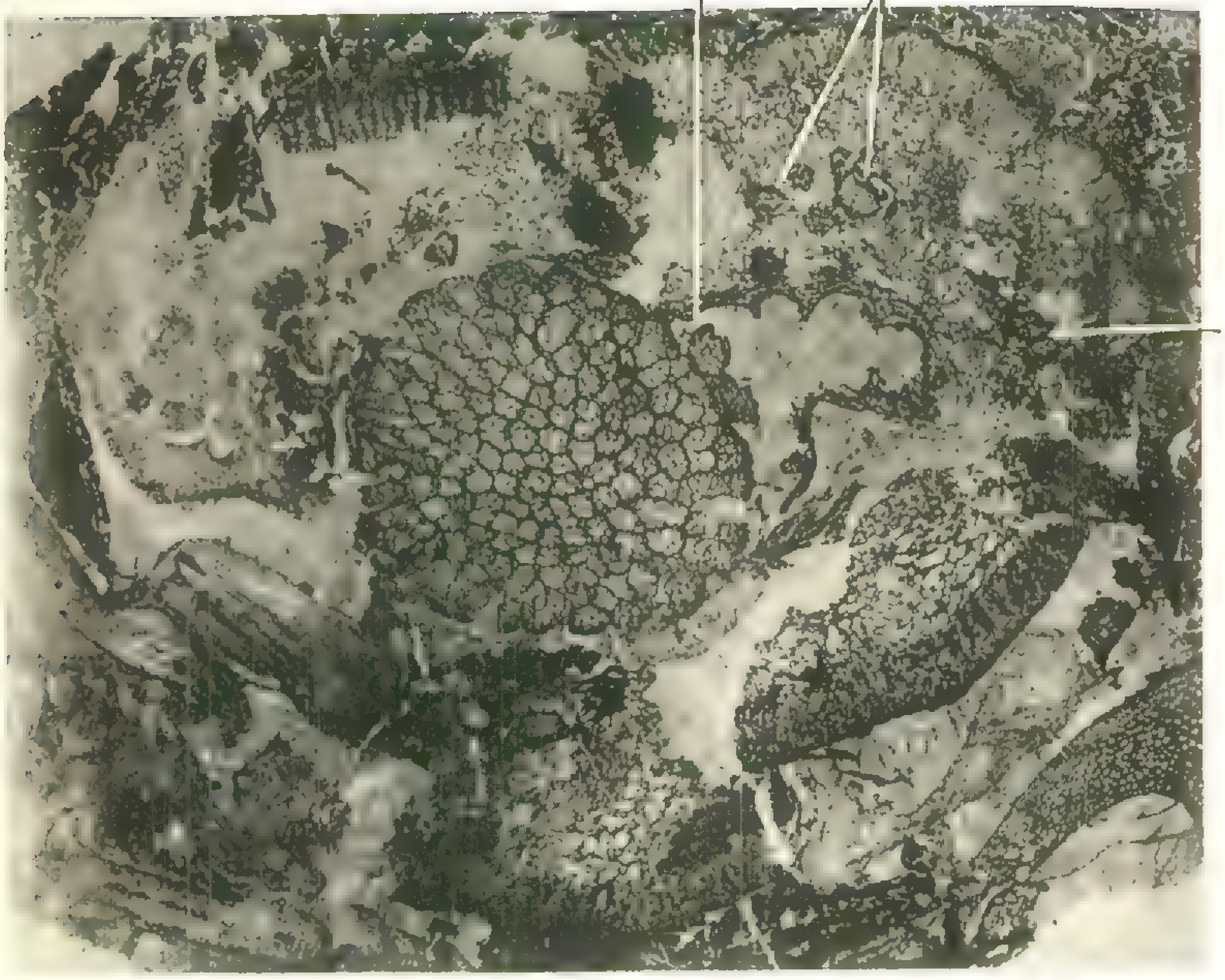
× 46. Slide S. 2791.

Fig. 7. Part of pericycle and inner cortex.

pc., pericycle, with numerous sclereides; *c.*, inner cortex with a large sclerotic plate.

× 33. Slide S. 2791.

Scott.



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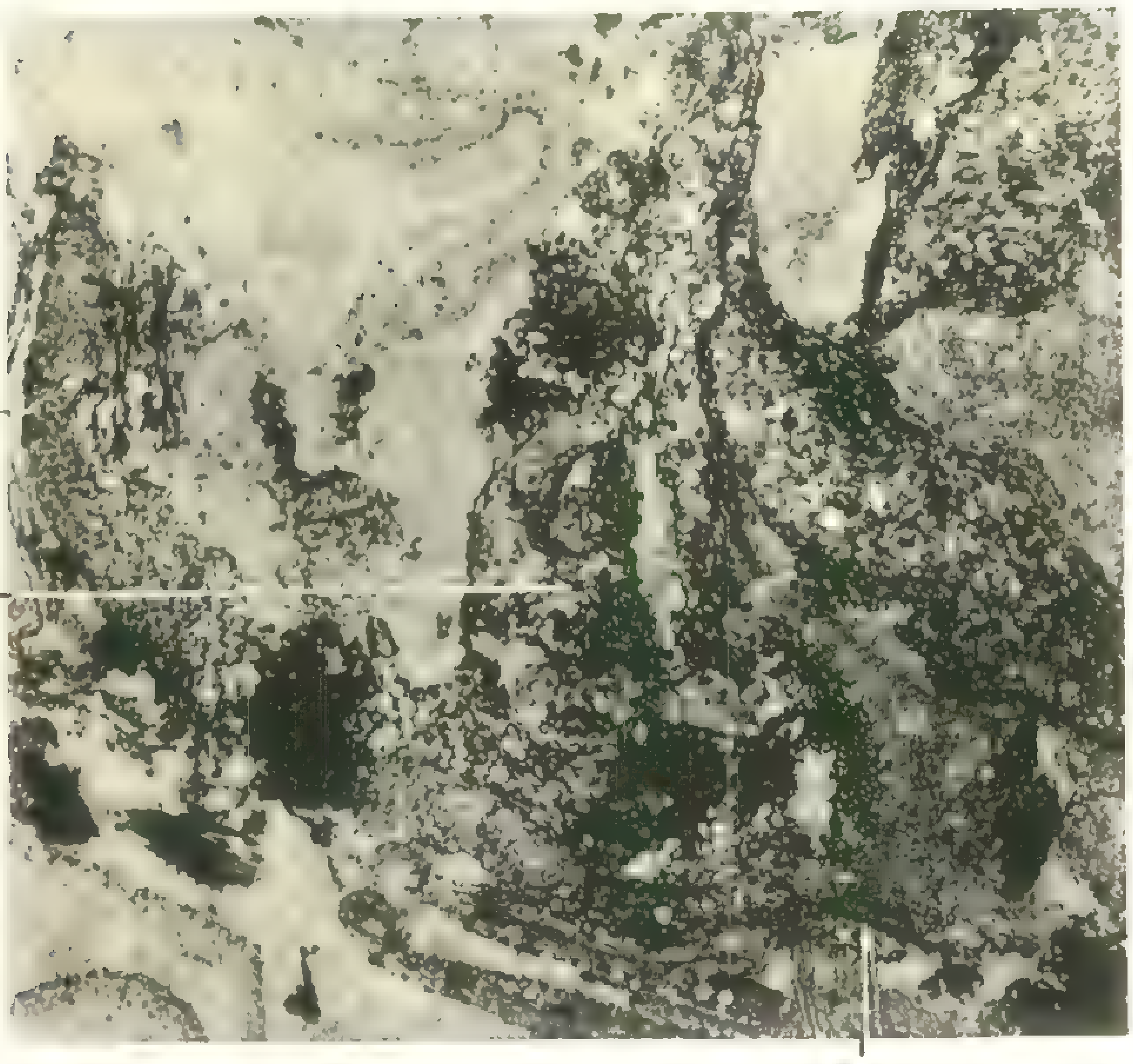

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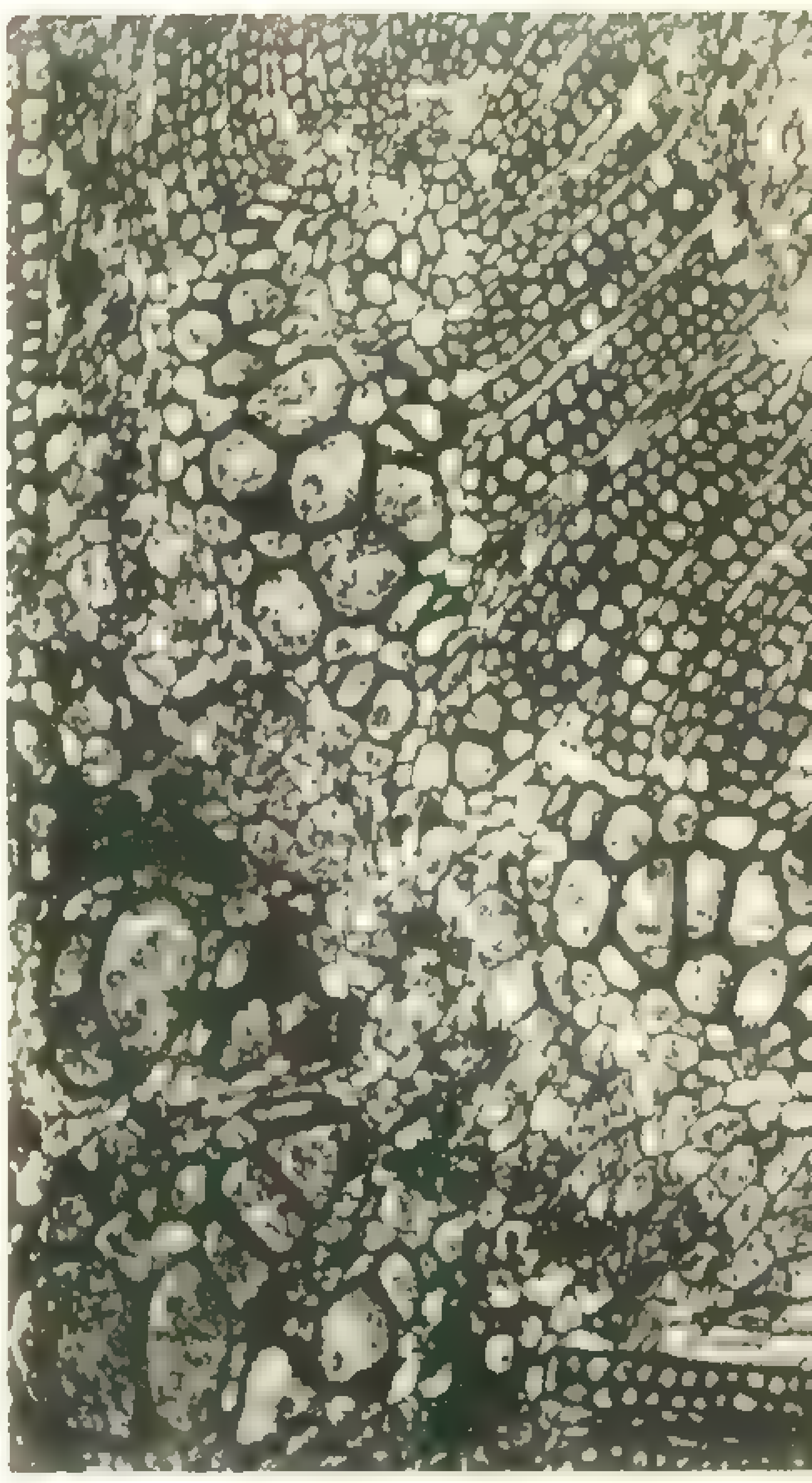

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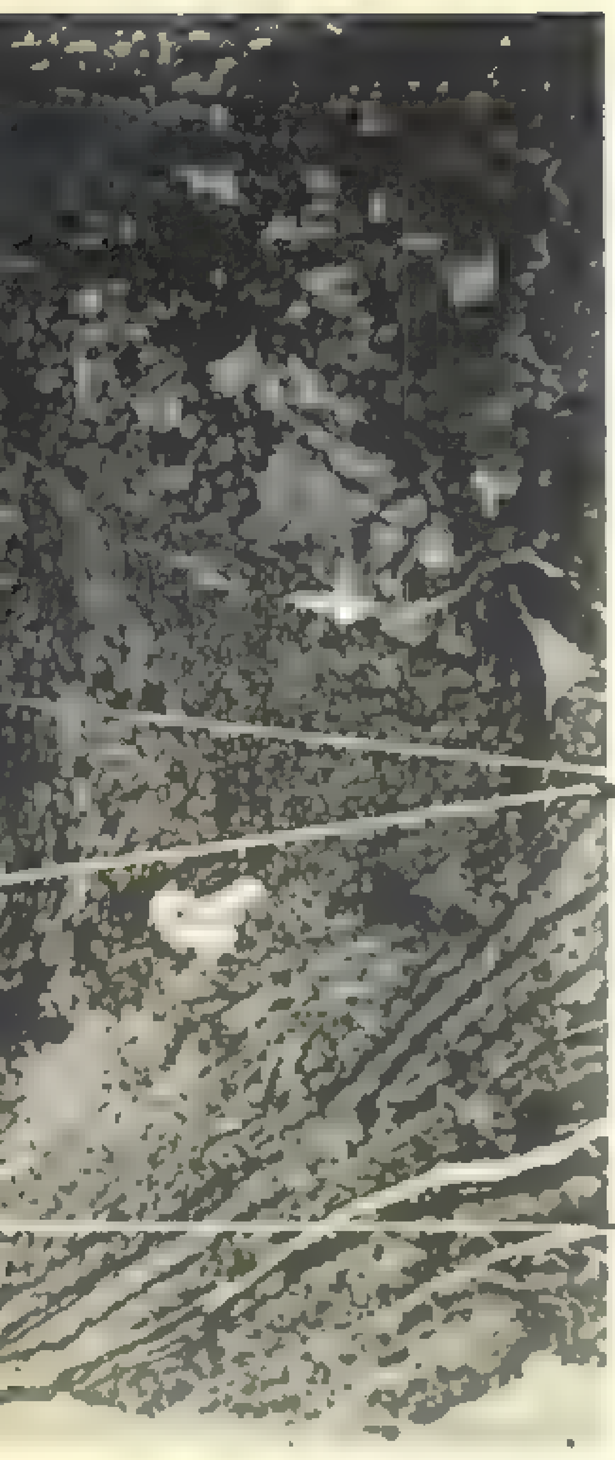

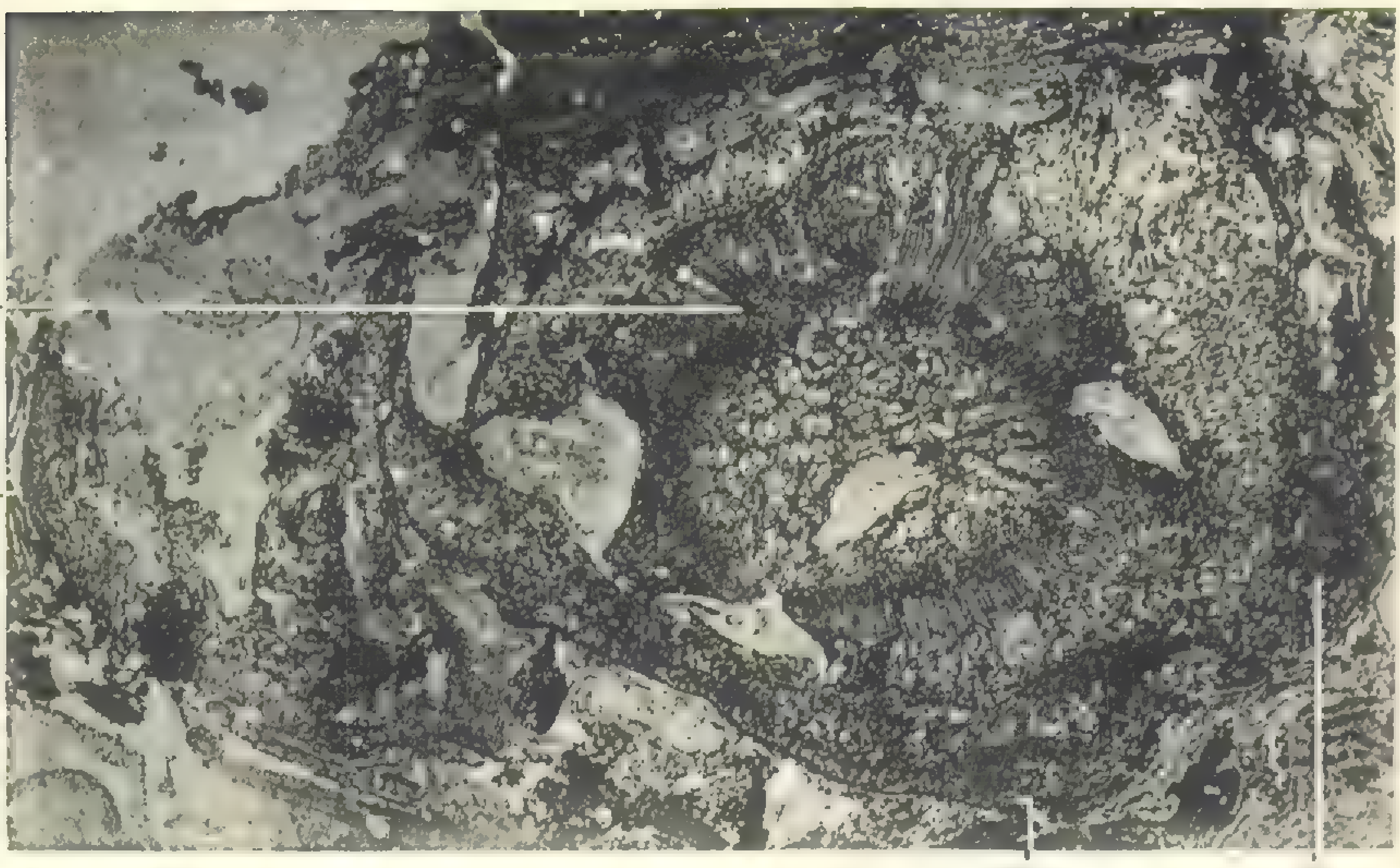

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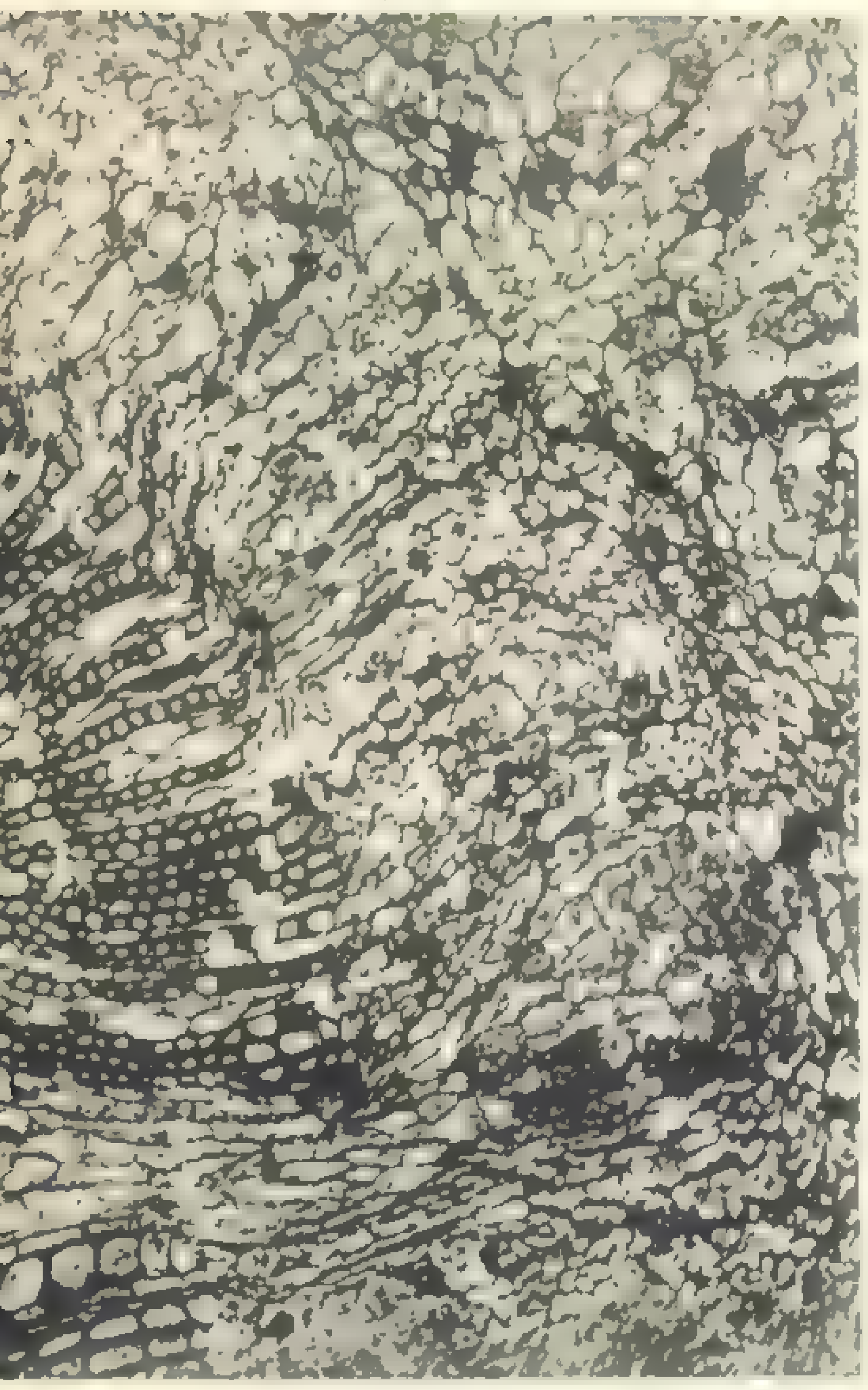

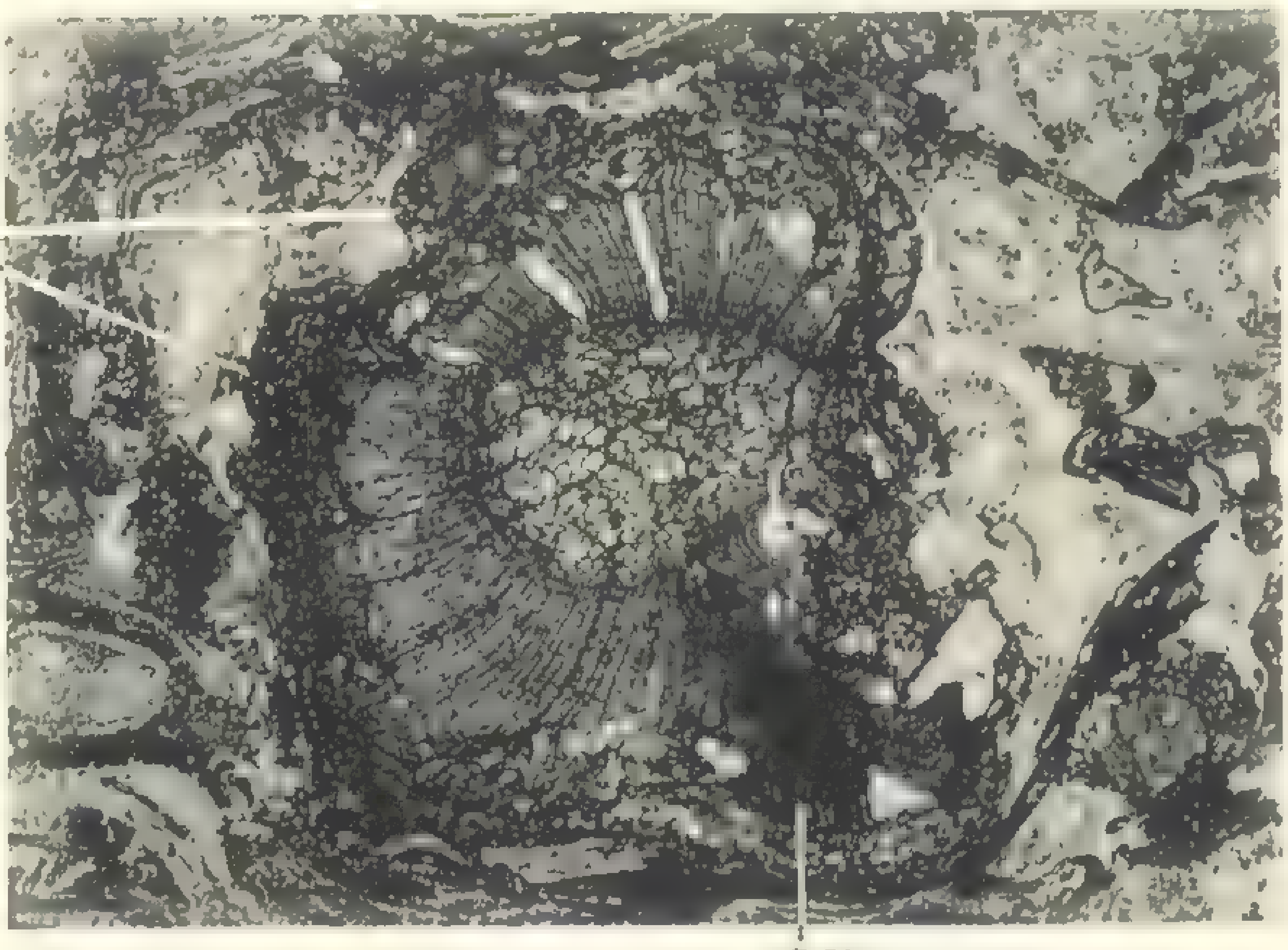

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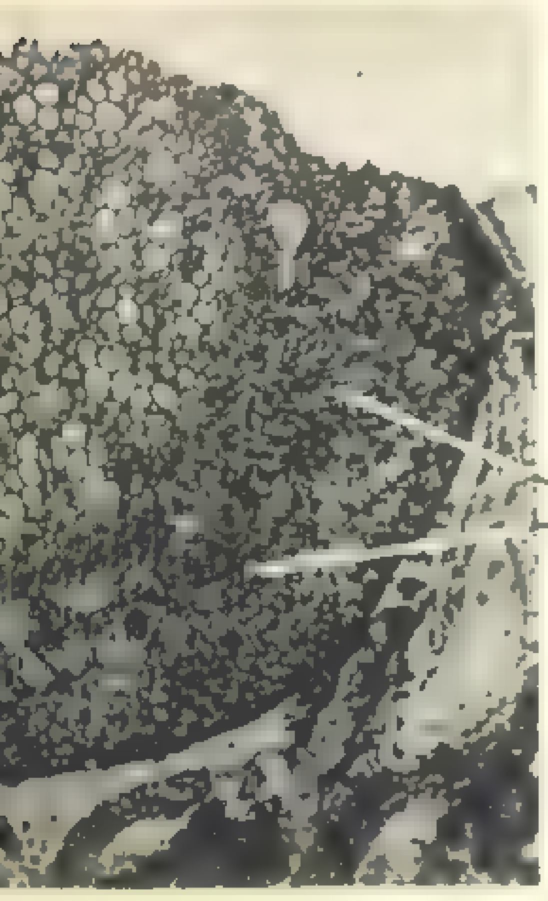

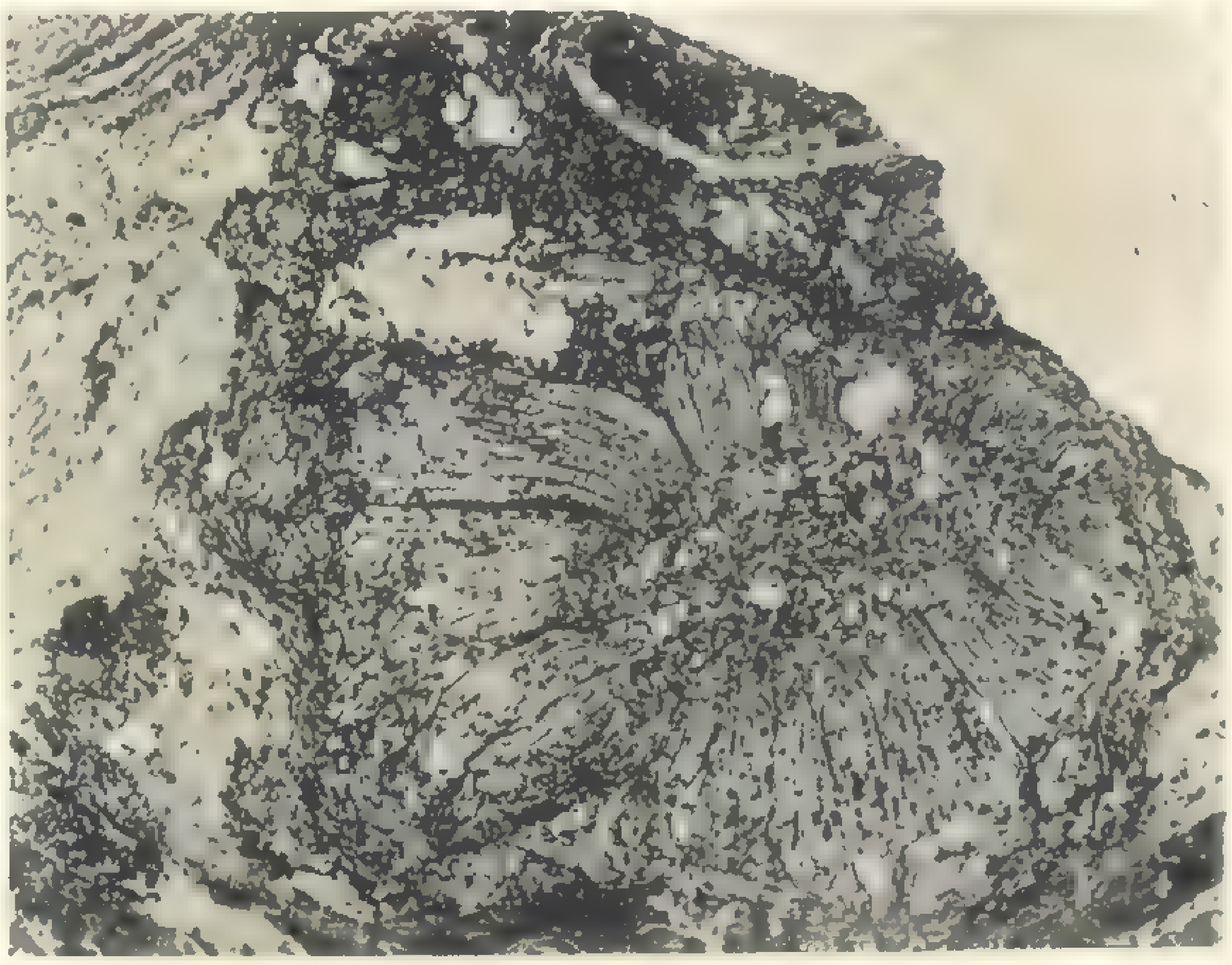

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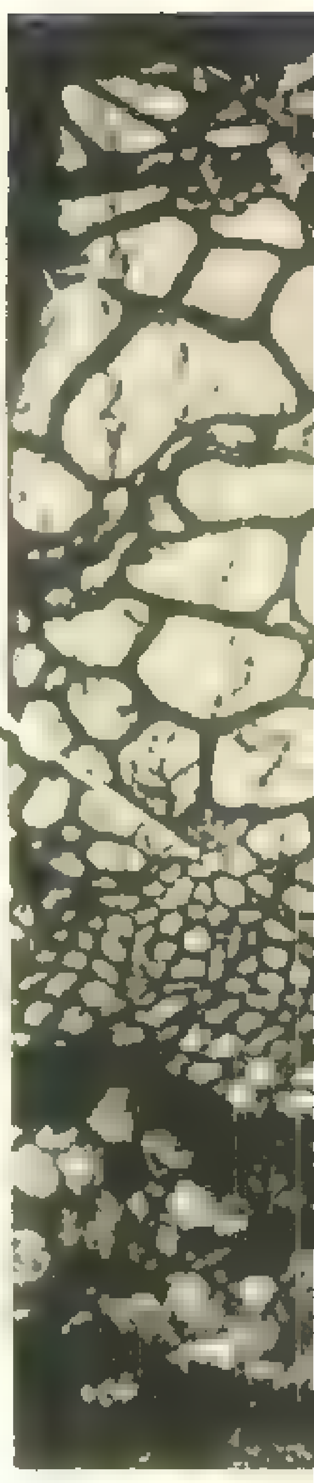

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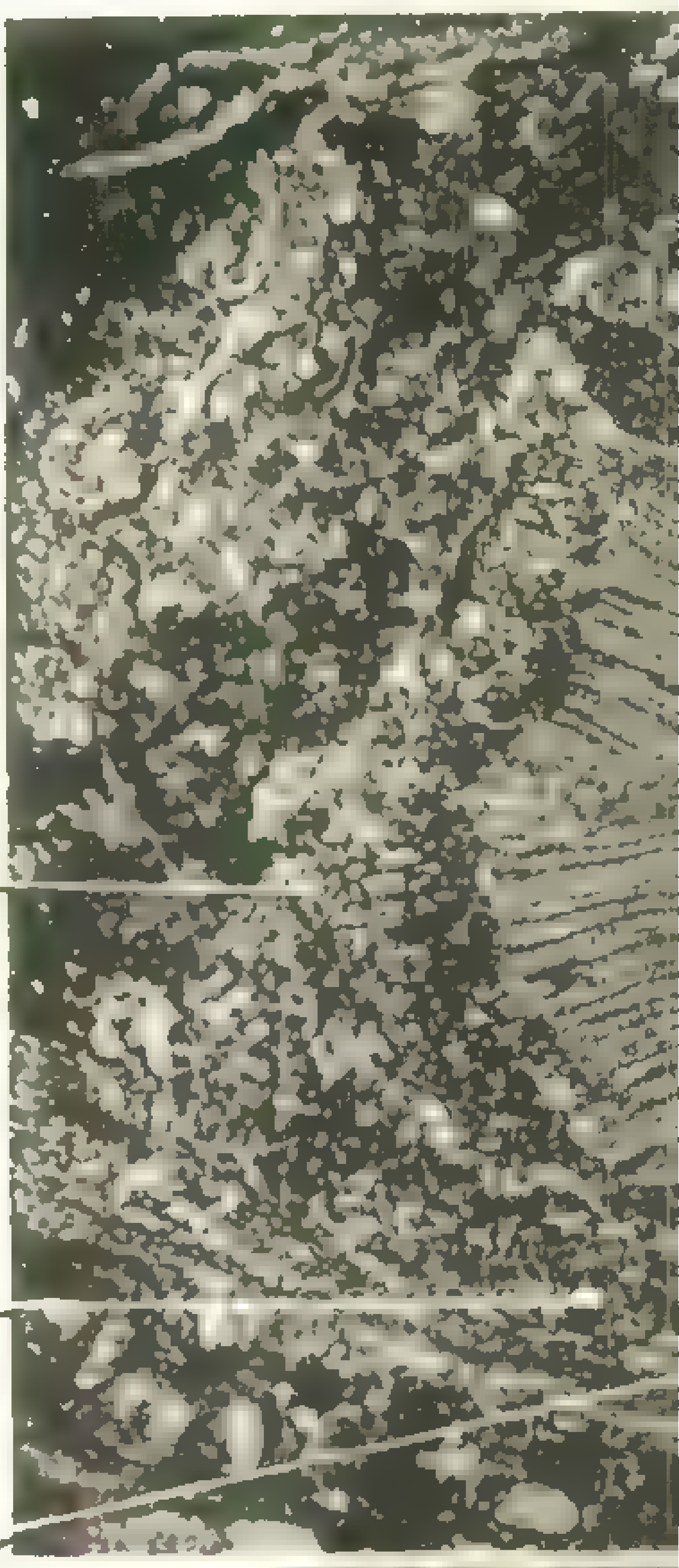

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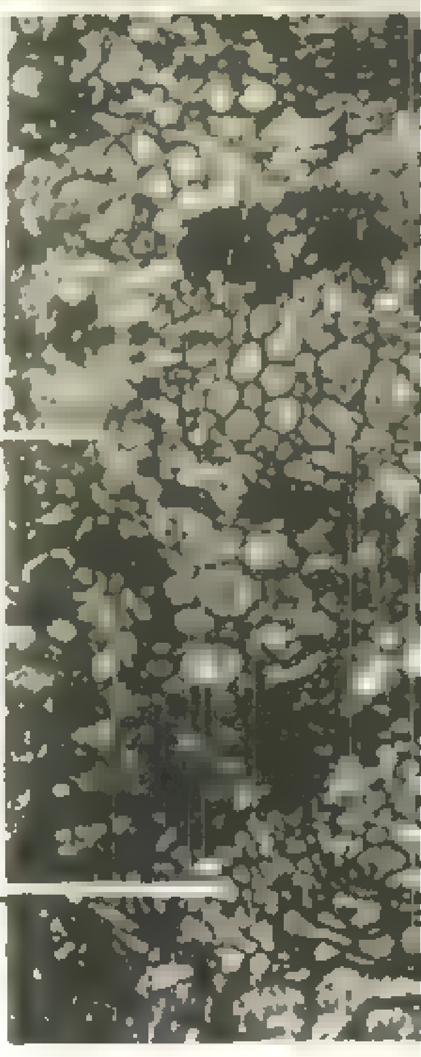

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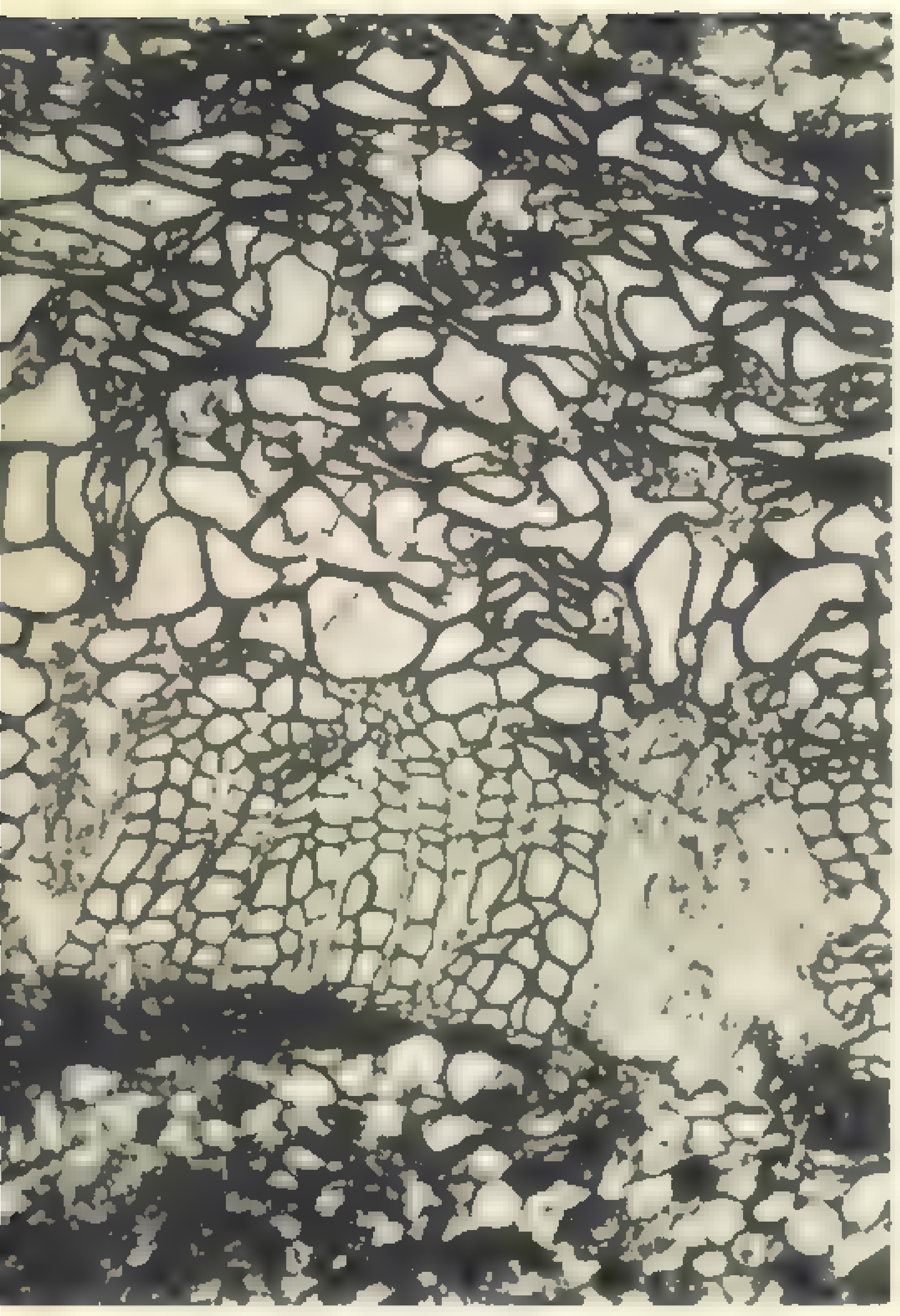

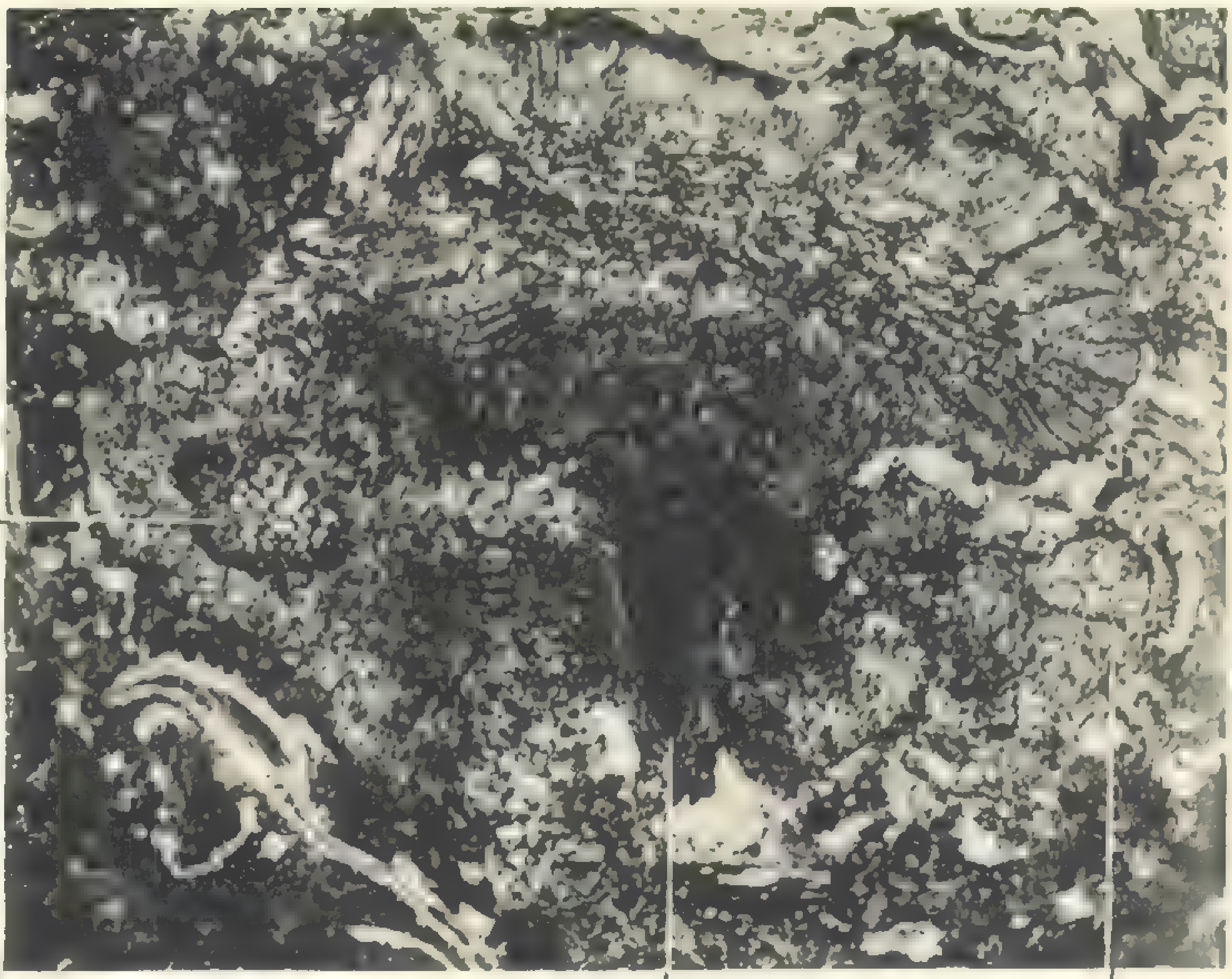

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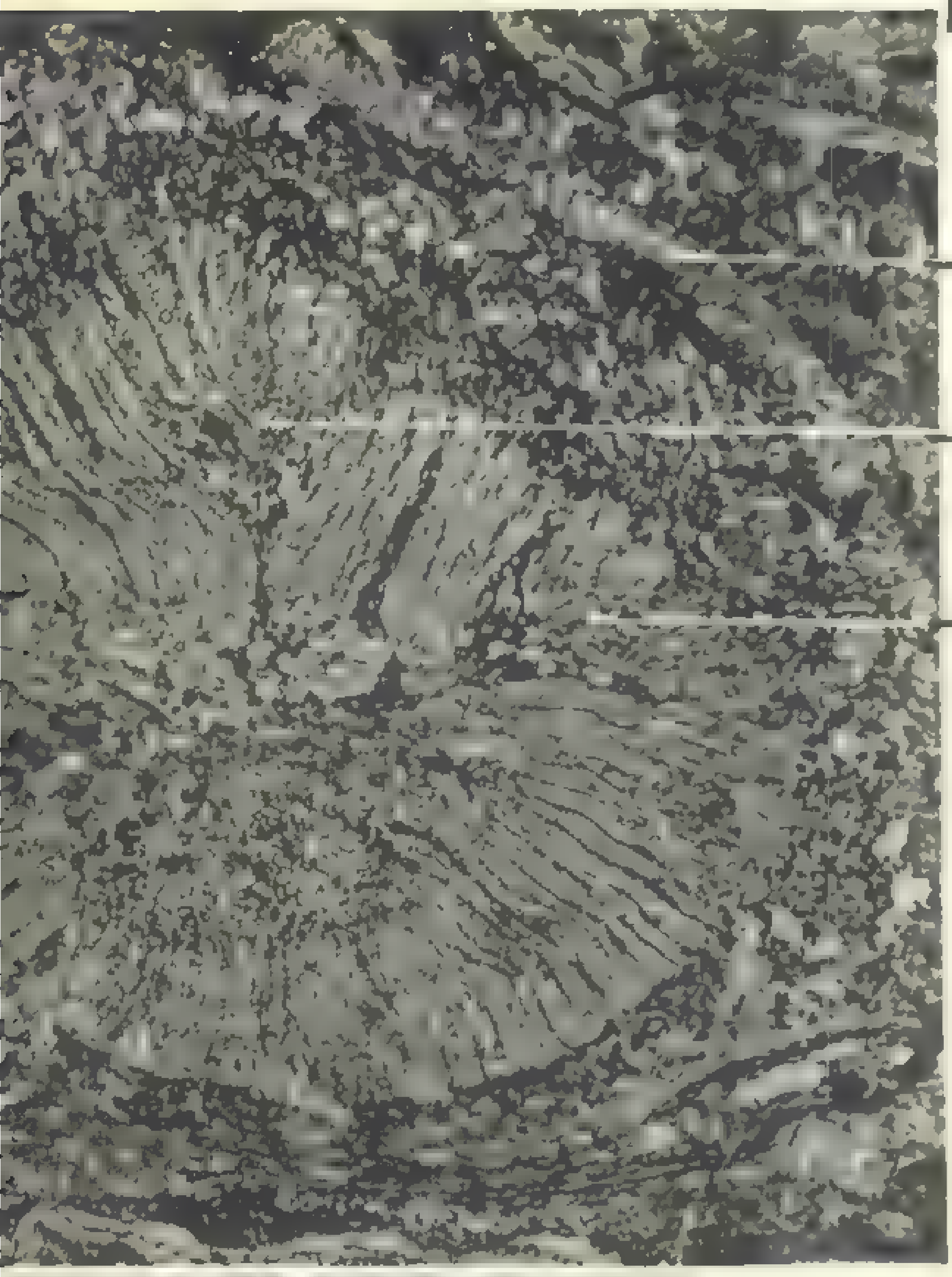

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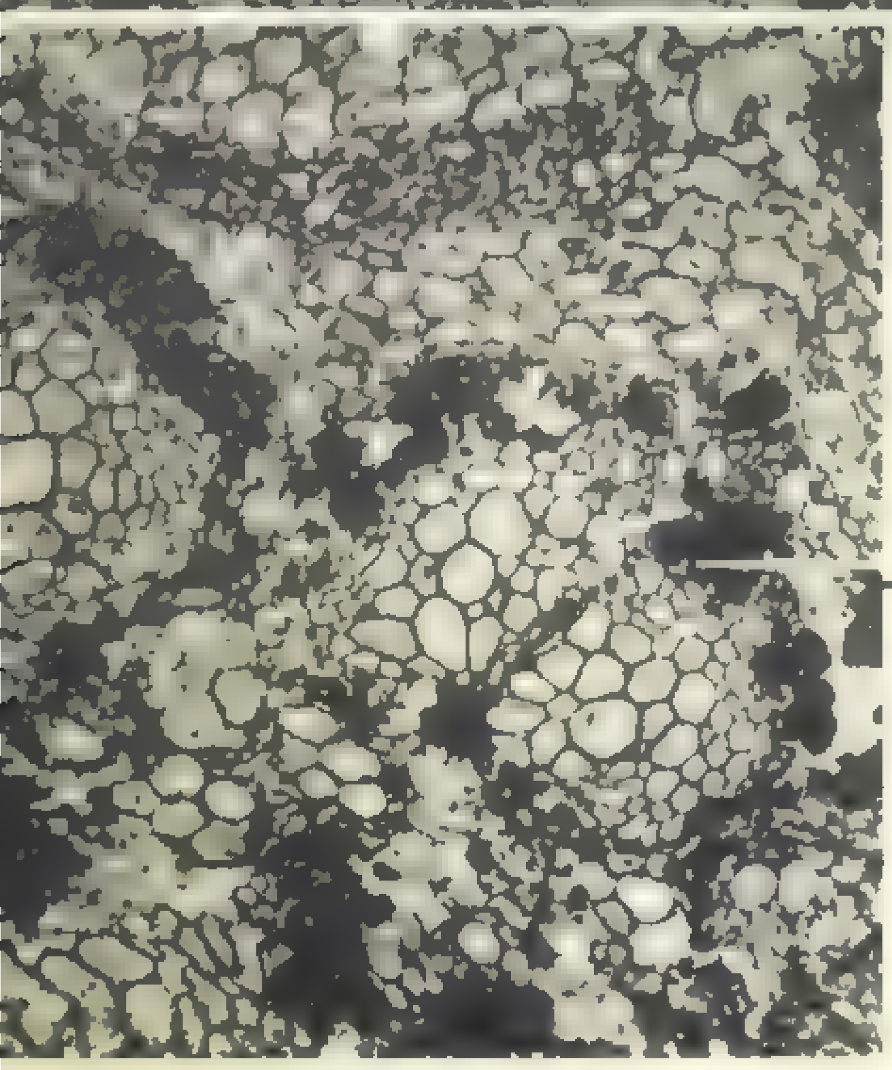

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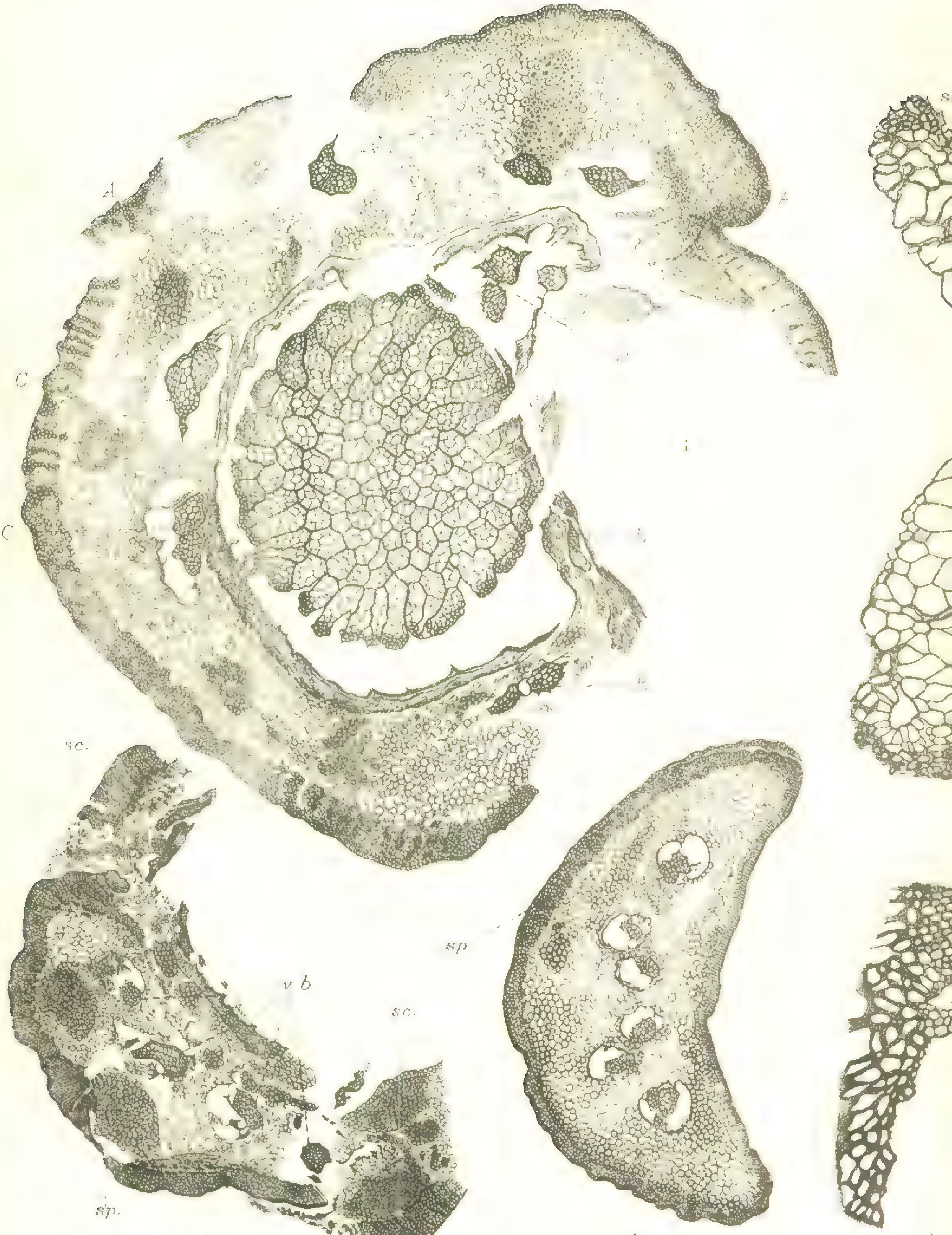

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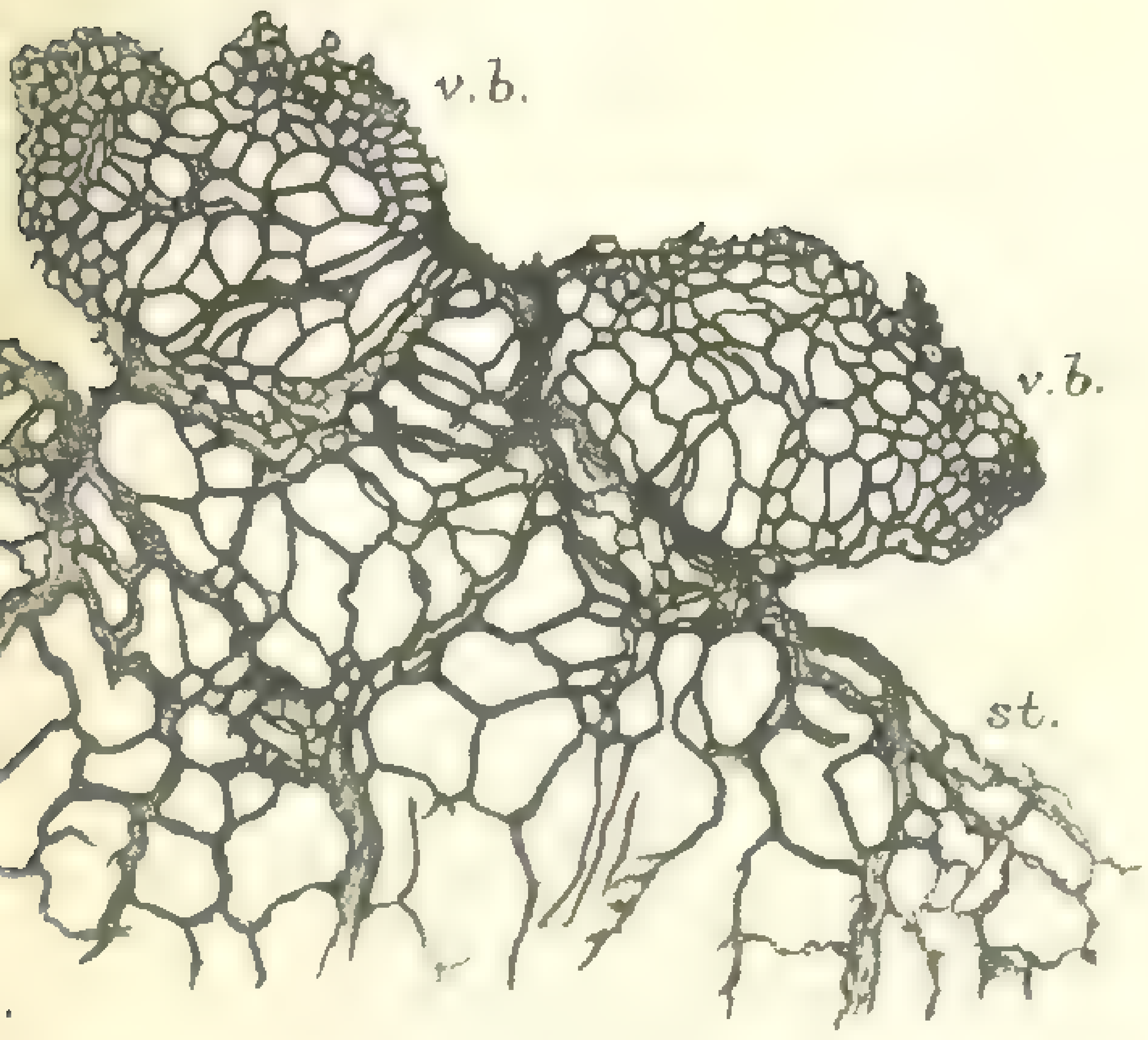
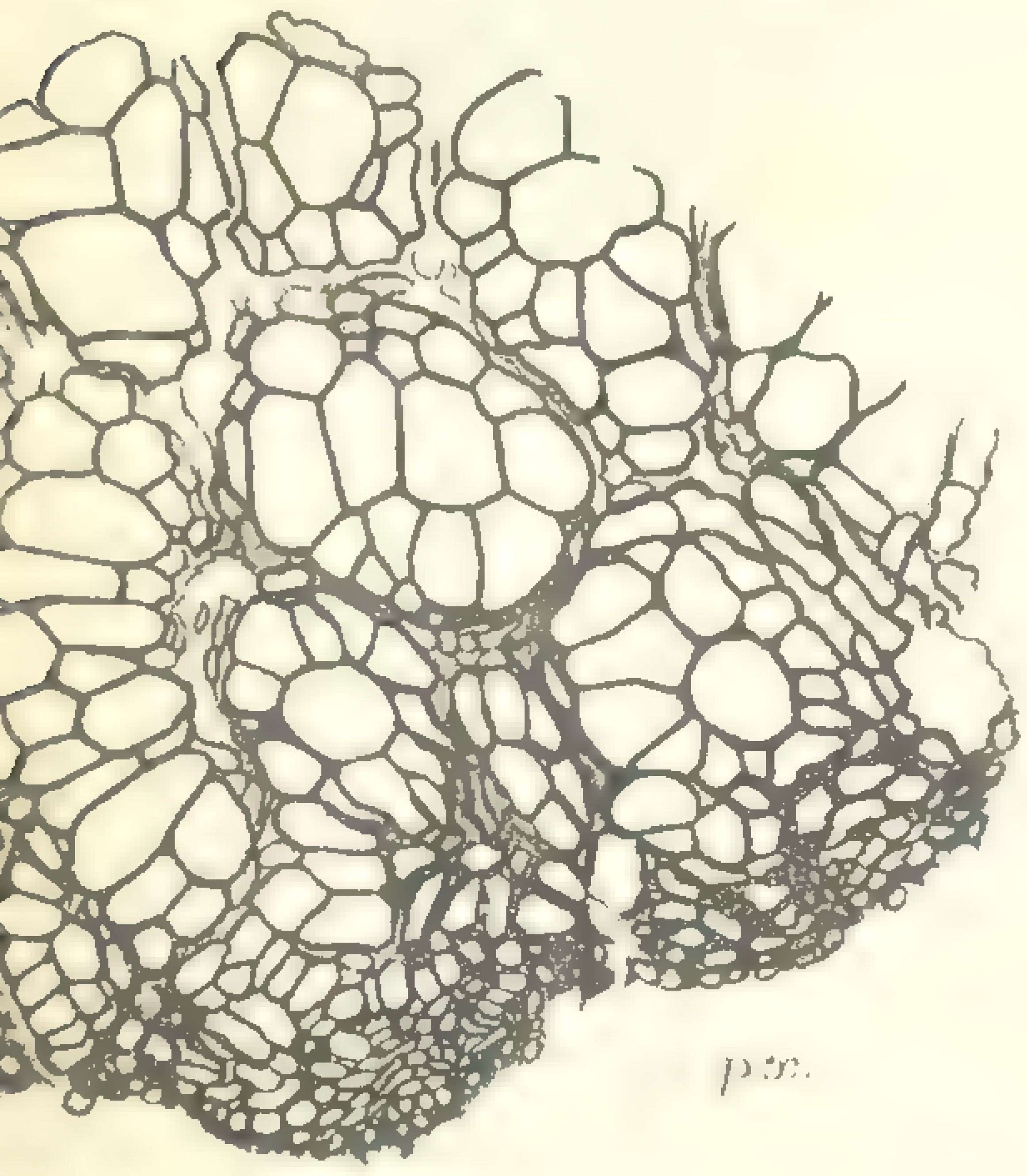
1–7 HETERANGIUM





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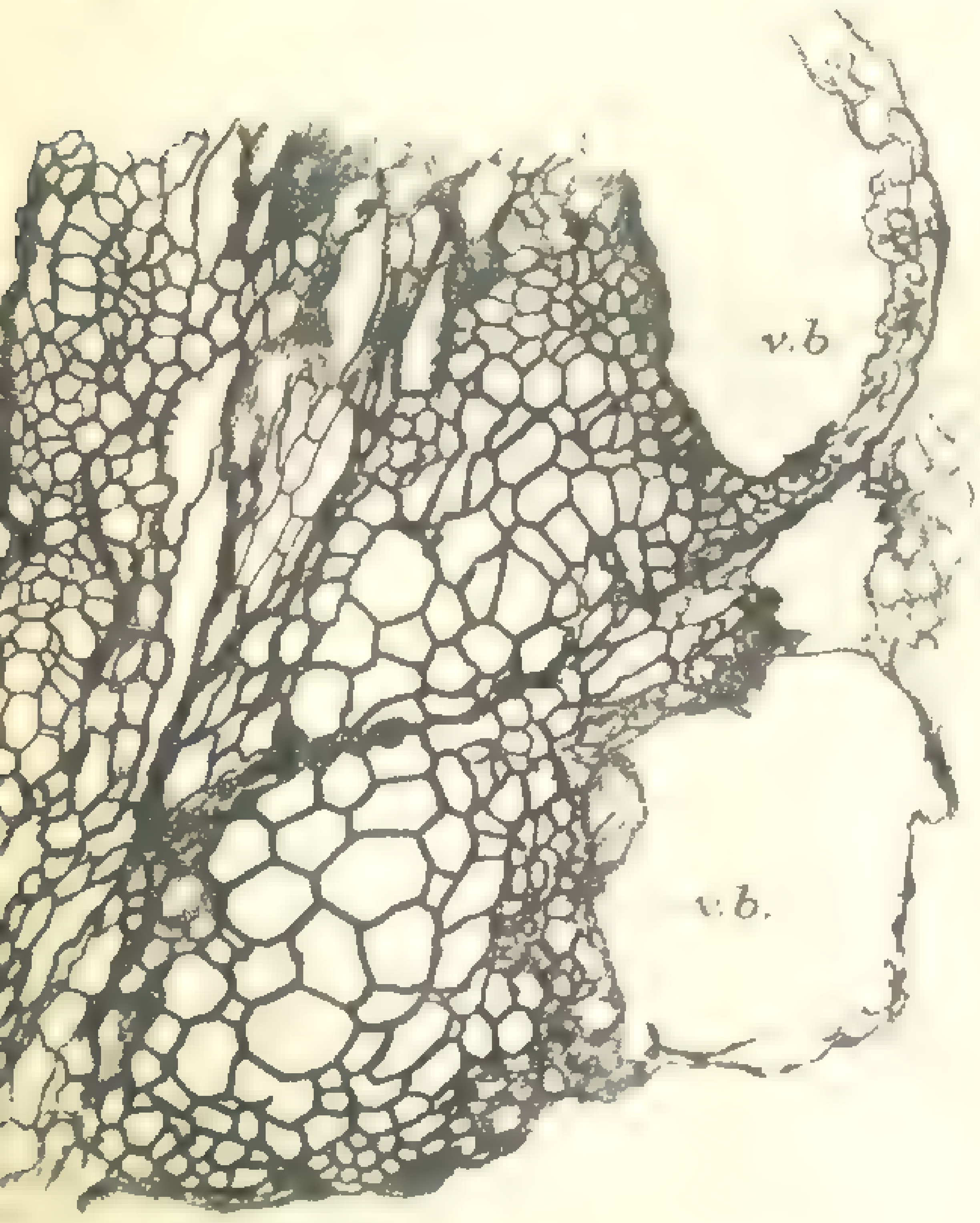

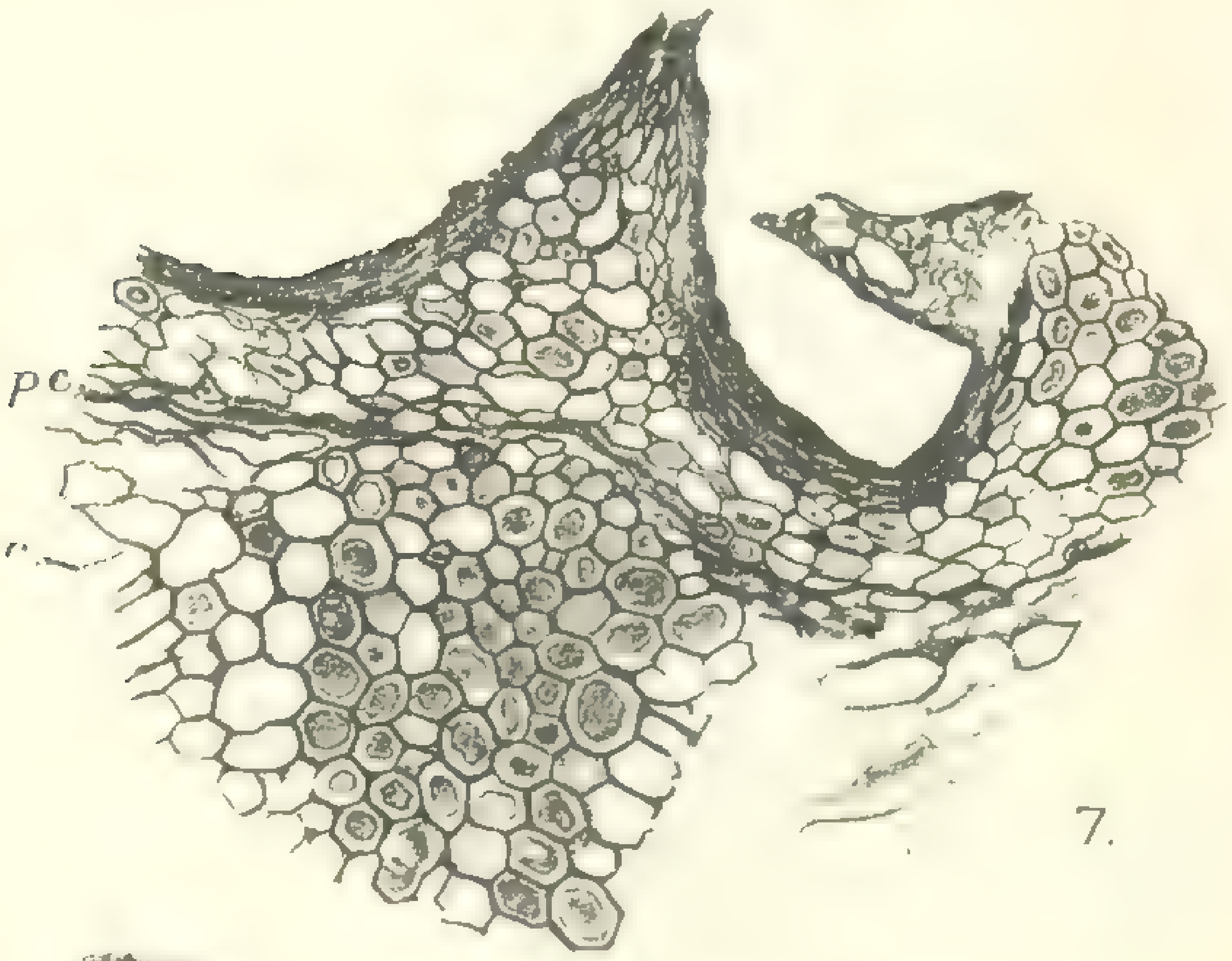

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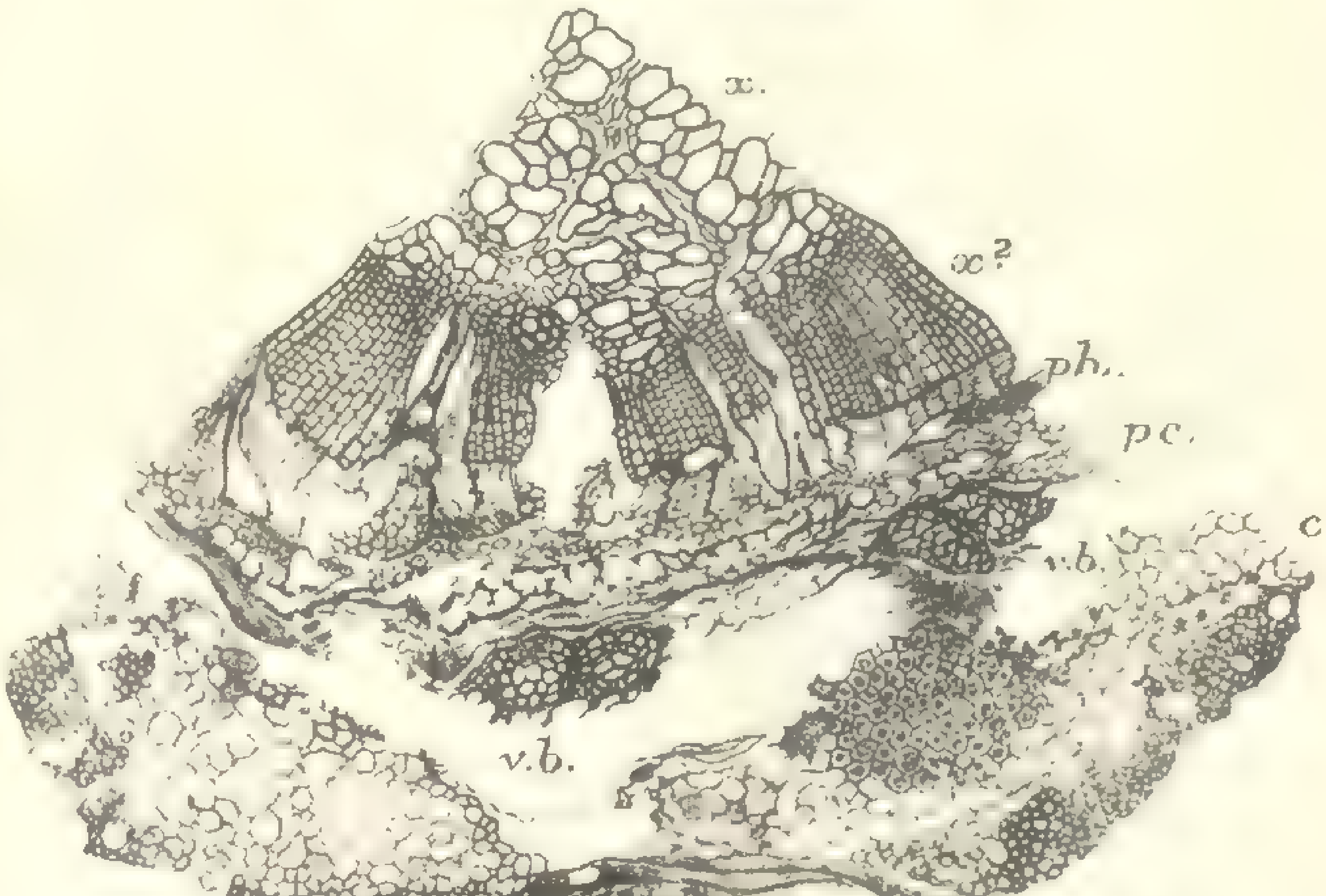

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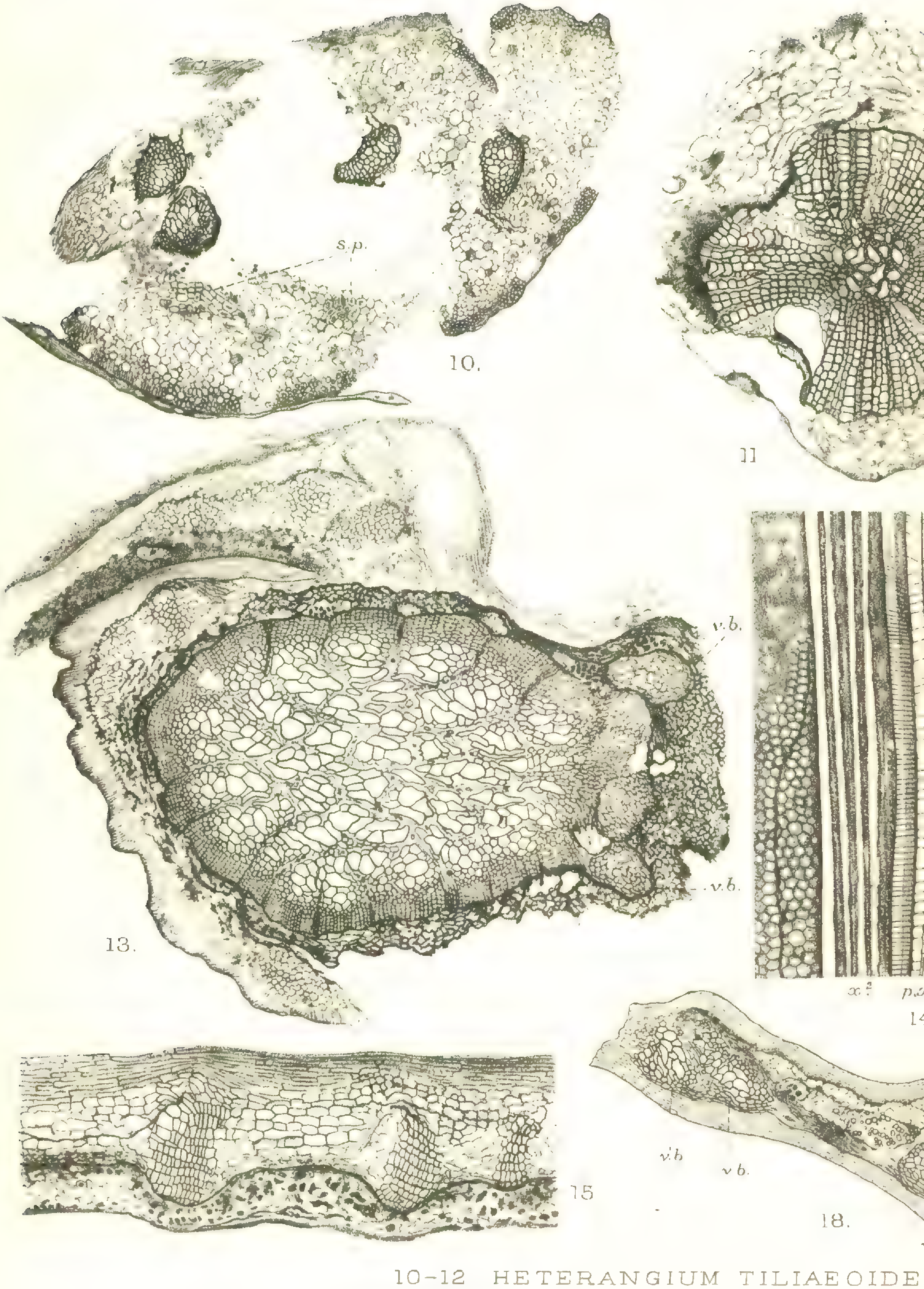
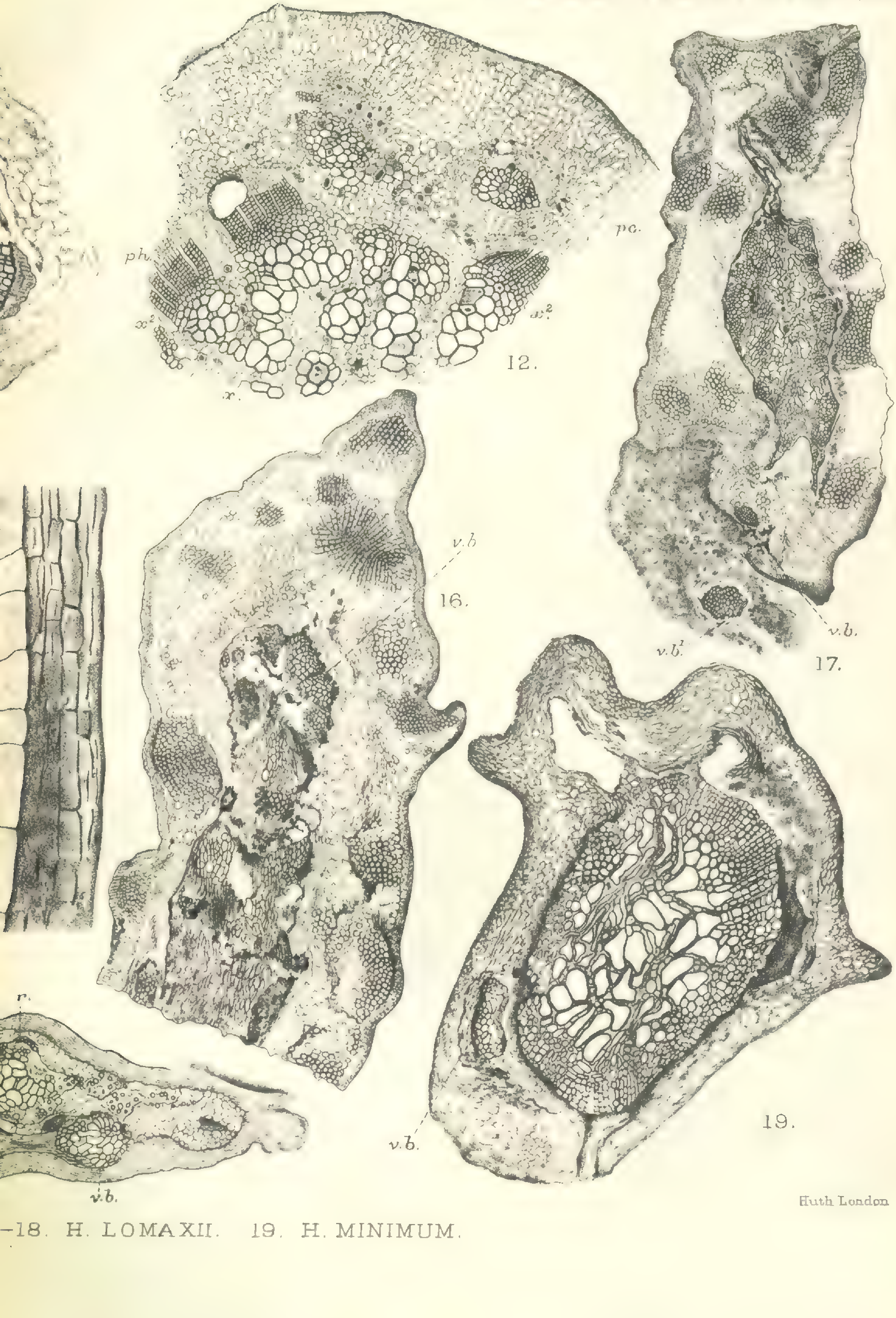


10–12 HETERANGIUM TILIAEOIDE



Huth London

–18. H. LOMAXII. 19. H. MINIMUM.

Figs. 8–12. *Heterangium tiliæoides.*

Fig. 8. Transverse section of stem from specimen 3, showing two leaf-traces.

v.b.[1], inner trace consisting of two bundles starting from stele; *v.b.*[2], outer trace, consisting of two bundles in the pericycle, each showing signs of division; *pc.*, pericycle; *c.*, portions of cortex.

× 9. Slide, Univ. Coll., N. 12.

Fig. 9. Part of stem from the same series, higher up, showing the outer trace (*v.b.*), now in the cortex, and consisting of two double bundles.

x., primary, *x.*[2], secondary xylem of stele; *ph.*, phloem; *pc.*, pericycle; *c.*, cortex.

× 12. Slide, Manchester, Q. 58.

Plate 4.

Fig. 10. Detached petiole, containing four distinct bundles. *s.p.*, sclerotic plates.

× 18. Slide W. 1624.

Fig. 11. Transverse section of adventitious root, tetrarch or possibly pentarch, with secondary wood; outer cortex probably missing.

× 30. Slide, Univ. Coll., N. 12.

Fig. 12. Part of young stem, from specimen 4, showing a double leaf-trace.

x., primary, *x.*[2], secondary xylem of stele; *ph.*, phloem; *pc.*, pericycle in which the two strands of the leaf-trace are embedded. *Cf.* Pl. **1**. Phot. 8.

× 18. Slide S. 1323.

Figs. 13–18. *Heterangium Lomaxii.*

Fig. 13. Form *β*. Transverse section of stem, specimen 2, showing stele with a small amount of secondary wood, pericycle, and cortex.

v.b., *v.b.*, the two bundles of the leaf-trace; the two protrusions of the wood between them are connected with the bases of adventitious roots.

× 15. Slide S. 445.

Fig. 14. Form *β*. Part of the xylem in radial section, passing through a peripheral strand.

px., protoxylem; *x.*, primary, *x.*[2], secondary xylem-elements.

× 133. Slide W. 1915. R.

Fig. 15. Form *β*. Part of the cortex in radial section, showing the *Sparganum* hypoderma on the outside, three sclerotic masses in the inner cortex, and pericycle below.

× 20. Slide, Manchester, R. 638.

Fig. 16. Form *α*, specimen 2. Transverse section of stem, showing the crushed stele, with a possible double leaf-trace (*v.b.*), pericycle, and cortex; in the latter the large and numerous sclerotic masses are conspicuous.

× 10. Slide S. 236.

Fig. 17. Form *α*, specimen 2 *a*. Transverse section of a smaller stem. A double leaf-trace is passing out.

v.b., one of the two strands in the outer cortex; *v.b.*[1], the other strand displaced.

× 7·5. Slide S. 236.

Fig. 18. Detached petiole, transverse.

v.b., the four bundles of the petiole; *r.*, an intrusive root of the "*Kaloxylon*" type.

× 30. Slide S. 236.

Heterangium minimum.

Fig. 19. Transverse section of stem.

v.b., leaf-trace beginning to divide.

× 32. Slide S. 1813.

HOOKER LECTURE:

THURSDAY, 7TH JUNE, 1917.

BY PROFESSOR F. O. BOWER, F.R.S., F.L.S.

HAVING for over thirty years occupied the Chair of Botany which Sir William Hooker rendered famous by two decades of strenuous work,—in the University of Glasgow where Sir Joseph Hooker graduated,—it seems apposite for me to take as the subject of the Hooker Memorial Lecture *the Natural Classification of Plants*. For no greater Systematists than the two Hookers existed during their own period. And I may be pardoned if I draw my illustrations largely from the group of the Filicales, since Sir William Hooker was the greatest of descriptive Pteridologists.

The life-work of the Hookers, father and son, bridged a critical period in the progress of Natural Classification. A vital difference of view separated their outlook on living organisms. Sir William was the very embodiment of the older *régime*, which laboured under the dogma of fixity of species. Sir Joseph was the first botanical exponent of the belief that species are mutable. Between them came Charles Darwin, who created that complete change of outlook which followed on the publication of the 'Origin of Species' in 1859. The effect upon Natural Classification, brought about by this revolution of thought, is the theme I shall endeavour to discuss.

It will not be necessary to refer in detail to the earlier history of Natural Classification. We need do no more than take passing note of archaic efforts. The recognition and naming of plants must have been initiated by primitive man, for plant-names figure in all languages. More specific designation and delineation were introduced as a consequence of the application of plants to practical uses as foods, or medicines, or in the arts. The mediæval Herbalists depicted many such forms; but they treated them rather as isolated phenomena, illustrating the ability of the Creator, than as having any nearer causal relation. Their similarities led to their grouping into families; but the very likeness which the members of these families showed was regarded as exhibiting ingenious variation upon a divine plan of construction. And so, amid admiration tinged with reverence, there grew up Systems of Classification, chiefly founded upon external similarity. Such early schemes are described as "artificial," for they were based upon few qualities, and those arbitrarily selected. Convenience was the motor impulse

of their construction. The System of Linnæus was the culmination of such efforts. But later the method became more "natural," being based, like that of De Jussieu, upon a wider area of diagnostic features. This change led up to the period, about the opening of the 19th Century, when Sir William Hooker began his life's work. He joined with vigour in the recognition, delineation, and description of new forms, and the classification of them in their natural affinities. Under his hands the Glasgow Garden became one of the most notable in Europe. The port of Glasgow traded with every quarter of the globe. This gave unusual facilities, and Sir William used them to the full. The result was that amazing output of descriptive work which marked his tenure of the Glasgow Chair, and it was continued at Kew till the end of his life in 1865.

The five volumes of the 'Species Filicum,' condensed and crystallized later into the 'Synopsis Filicum,' constituted his *magnum opus*. It may be taken as a typical example of the best systematic works of the immediate Pre-Darwinian Period. It gives an insight into the method of its author, and in some degree reflects his outlook. The work is analytic rather than synthetic, though flashes of synthetic inspiration are scattered through its pages. It describes, from personal observation and in meticulous detail, a vast number of forms. The specific diagnoses and records of distribution are a veritable mine of exact statement, which later systematists have freely worked. But the author did not originate any new system. He adopted and modified that of Presl's 'Tentamen.' The chief merit of the book will always rest upon what its very title conveys—that it gives a conspectus of all the then known species of Ferns. The limits of the genera in which those species were grouped gave rise to differences of opinion with other writers. Presl had published his 'Tentamen' in 1836, somewhat earlier than Sir William Hooker's beautifully illustrated work on the 'Genera Filicum.' Comparison of the two books shows that there is a wide discrepancy in the number of their genera. Where Presl recognized 132 genera, Hooker retained only 75. This at once indicates a salient feature of his method. He merged many genera, ranking them as sub-genera under more comprehensive headings. One reason for this was his mistrust of anatomical data, of which Presl made great use. But at least one other reason influenced him,—that of convenience in diagnosis. An example will illustrate this point. In placing *Plagiogyria* under *Lomaria* he objects to the use of its oblique annulus as a diagnostic character, because of its requiring microscopic examination, and the inconvenience "in a work whose main object is to assist the tyro in the verification of genera and species." Natural habit, he remarks, is often a safer guide than minute microscopic characters. And further, he states that "those Botanists who have showed themselves peculiarly addicted to multiplying genera have not always taken Nature as their guide, nor succeeded in eliciting a simple and tangible arrangement."

It thus appears that convenience of application was at times admitted by Sir William Hooker as a factor in his method.

Within the genus he grouped the species in a manner best illustrated in large genera, such as *Cyathea* and *Alsophila*. The species are arranged according to the complexity of branching of their leaves, from those which are entire or simply pinnate, to those with more complex branchings. In many genera the venation is used in diagnosis and grouping. A further segregation was made according to geographical distribution. These and many other characters are used; but it appears that they are called in for purposes of diagnosis rather than those of synthesis. The object of the author may have been in wish and intention to follow the dictates of Nature. But along with this went in practice the laudable desire to make the determination of species easy.

That the arrangement shown in the 'Synopsis Filicum' resulted in something approaching to a natural grouping of the Filicales is undeniable. Anyone, in the light of present knowledge, can criticise it in detail. But to denounce it as thoroughly artificial ("durchaus künstlich"), as Professor von Goebel has done, is grievously to underestimate the merits of a great systematic work *.

Nevertheless, it must be confessed that the arrangement of the Sub-Orders of the Filicales in the 'Synopsis' was in some measure according to tradition, or to chance. Circumstance rather than conviction appears to have dictated it. The placing of the Gleicheniaceæ first coincides with the arrangement in the 'Tentamen' of Presl. The sequence of other families corresponds frequently, though not in detail, to that of the Prag Professor. The relegation of the Osmundaceæ, Schizæaceæ, Marattiaceæ, and Ophioglossaceæ to the end of the book is probably a mere consequence of those families having been omitted from the 'Species Filicum,' and they appear in the 'Synopsis' as an addition (see Preface). Thus the arrangement of the Sub-Orders seems to have been for Sir William a relatively trivial matter, and it is certainly not according to Nature. But the intra-generic and generic groupings are often those which will take permanent place as knowledge increases, though this is certainly not the case invariably. We conclude, then, that the permanent importance of the work centres in the specific diagnoses, rather than in the limitation or arrangement of the genera, or larger groups. In this respect it is characteristic of those systematic works which were produced under the belief in the Constancy of Species.

The outlook of the Pre-Darwinian Systematist must have been highly unsatisfactory to any intelligent man. On the one hand, he found the

* This verdict, expressed in 'Flora,' 1896, p. 75, has been rebutted in detail elsewhere. "Studies in the Morphology of Spore-producing Members," Phil. Trans. vol. 192 (1899), p. 131.

deeply ingrained belief in the Constancy of Species. This doctrine, introduced originally by Linnæus as a summation of his experience, was for a century accepted by his followers as established truth. But, on the other hand, there was a growing sense of the kinship of living organisms. "Natural Affinity" was instinctively recognized as a consequence of close comparison. The instinct translated itself into methods of grouping together such forms as have prominent features in common into genera and families. Such relationship and consequent grouping was exemplified in all divisions of the Vegetable Kingdom. If this was merely a reflection of the plan of separate Creation of Constant Species, well might Elias Fries remark that there was "*quoddam supernaturale*" in the Natural System.

The fact is that the doctrines of independent creation, and of constancy of species are incompatible with the idea of affinity in the ordinary sense of the word. This was doubtless in the minds of the Systematists of the early 19th Century. But many of them, like Sir William Hooker, were content to expend their labour upon the recognition and record of those "affinities," without raising the inconvenient question of causality. Such difficulties vanished with the collapse of the doctrine of Constancy of Species, and the establishment of the theory of Evolution through Mutability. The results already achieved in Natural Classification then found a new interpretation. Affinity was held to mean some degree of relationship by Descent. A Natural Classification, if correctly constructed, would then be understood to visualise what remains of the evidences of Genetic History. In fact, Classification and Phylesis should coincide.

The question may, however, be asked by those concerned especially in Systematic Work, whether convenience is to be wholly ignored in the systematic arrangements in use at the present day. It has been seen that Sir William Hooker still admitted that convenience of application should modify the method he used in the 'Species Filicum.' Therein he, as a Pre-Darwinian, continued the practice which underlay, in more or less degree, all the antecedent Artificial Systems. A very real object before the early writers was readiness of identification of species believed to be distinct, though in some way related. An insistent question for us now, in the light of Evolutionary Belief, is whether or not convenience is still to be allowed to modify the systematic exposition of phyletic conclusions, so as to render identification practically easy? The answer should be a resolute negative. This is, indeed, the only answer for those who clearly see in Systematic Arrangement a reflection of Genetic History. But still some degree of convenience can be gained without the violation of affinities demonstrated by more minute analysis. When such demonstration has been given, it should still be possible to construct analytical keys, which would serve for ready systematic identification, without involving all of the exacting observations of the laboratory. But *in writing*

detailed Systematic Works the sole endeavour must be to arrange the material so as to indicate phylesis.

It seems easy at the present day to grant this in theory, but it is difficult indeed to carry it out consistently in practice. For it involves the whole problem of Natural Relationships, which should be based upon the sum of all knowledge relating to the organisms classified. It is then little matter for surprise that the change of outlook, necessarily following on the acceptance of Evolutionary Theory, reacted very slowly upon the Classifications current during the second half of the 19th Century. We may take as an example the *Magnum Opus* of Bentham and Hooker, the 'Genera Plantarum,' undoubtedly the greatest systematic work of the period. The object of the book was to formulate, on the basis of personal observation, the generic diagnoses of Flowering Plants. The grouping of those Genera into Orders, and the arrangement of the Orders among themselves were left substantially as in the systematic works current at the time: for instance, in the 'Prodromus' of De Candolle. The old Sub-Classes were retained. The Monochlamydeæ were kept apart as a separate Sub-Class, and the Gymnosperms were spliced in between the Dicotyledons and Monocotyledons. It does not follow, however, that this would be the considered opinion of the author of the Monograph on *Welwitschia.* It seems obvious that in a work, the value of which consisted in the definition of genera, the further problem of the grouping of those genera was not undertaken. The current groupings were retained so as not to raise questions apart from the immediate task. However deeply Sir Joseph Hooker's mind was imbued with evolutionary belief, such views were not obtruded in the text of the joint authors. Nevertheless, those who study the last sections of the Ordinal Diagnoses of the 'Genera Plantarum' will find indications of affinity far in advance of the Classification which the authors had retained. But since the general scheme of arrangement followed that in vogue in Pre-Evolutionary days, the 'Genera Plantarum' may be classed as technically belonging to that period. We thus see that the effect of the Dogma of Constancy of Species, as reflected in Systematic books, lasted long after it had ceased to hold the field. The reason for this is to be found in the impossibility of remodelling the broader lines of classification until time had familiarized the new aspect of old facts; and it was necessary to wait till the multitude of new facts essential for full argument should have been acquired.

It might thus seem to the superficial observer as though Natural Classification had benefited little by the advent of Evolution. The charge of ultra-conservatism, or even of inconsistency, might ignorantly be laid against great men of science, such as Bentham and Hooker; though the only possible ground for such a charge might actually be their unwillingness to force a change prematurely. This is probably the chief reason why,

for long after the publication of the 'Origin of Species,' the Natural Classification of Plants was still concerned rather with the distal twigs than with the main branches of the Evolutionary Tree. Even now, the question whether there was really a single trunk is unsettled, not only for the Vegetable Kingdom at large, but also for its chief Divisions. Such questions as the genetic relations of the Bryophytes and Pteridophytes: or of the Gymnosperms and Angiosperms: of the inter-relations of Mosses and Liverworts, or of the several phyla of Pteridophytes, are still matters of speculation rather than of demonstration. Nevertheless, the assembly of the members of each into genera, and groups of genera, is already well advanced. The sequence of steps is naturally backwards from species and genera to groups of genera, and orders: and thence to groups of orders. But the argument proceeds from the distal to the proximal with ever increasing uncertainty. Natural History is in fact like any other history—a cult which is liable to lose its precision as it extends backwards into the mists of the past.

In 1909 the sixth edition of Engler's 'Syllabus of the Families of Plants' was published. It contains on its opening pages a statement of the "Principles of Systematic Arrangement." This, though not by any means exhaustive, may yet be taken as an Index of the point of view entertained exactly fifty years after the appearance of the 'Origin of Species.' It is true that it relates almost entirely to Flowering Plants, as is natural since Professor Engler has been chiefly engaged upon them. Using freely the observational results acquired by such predecessors as Braun, Eichler, Bentham, and Hooker, he has proposed extensive re-arrangements of the Families of Flowering Plants, in accordance with the phyletic views set forth in his Introduction to the Syllabus. Apart from those statements which have their special reference to Flowering Plants, he enunciates among his Principles some which are of general application. For instance, the facts of Ontogeny are held to be of the first importance, as reflecting the probable course of Descent. But it is pointed out that the facts of progress of individual organs from a phyletically early state to the advanced are not usually available. It is recognized that a character of value for comparison in one circle of affinity may be valueless in another. On the other hand, those characters which remain constant in a phylum are of special value in its comparative treatment. Insistently the question will arise whether parts relatively simple in character are actually primitive, or the result of reduction. The value of anatomical data is freely acknowledged; but those characters which are not in direct relation to external conditions are to be estimated more highly than those referable to adaptation. Combinations of progression in characters independent of one another are recognized as specially important. Finally, the facts

of Palæontology are held as trustworthy, so far as they go. These are among the principles which may be observed in the quest of a Natural, that is essentially a Phyletic Classification.

Those engaged in such enquiry will assent to the soundness of Professor Engler's Principles, which are indeed substantially those which were already in general use. But the feeling most prominent in the mind, after reading his statement of them, will be the hopelessness of the full realization of the quest under present conditions, in the case of Flowering Plants. The weakness of the evidence is specially marked in respect of the two lines which should be most prominent: viz., Anatomy, and the Palæontological record. Vascular Anatomy in Phanerogams has been robbed of its chief phyletic interest, as Dr. D. H. Scott has indicated, by the disappearance of the old centripetal wood, and the substitution of the new centrifugal wood, which is secondary both in the individual and in the race. Only vestiges of the old wood remain in some few Gymnosperms. In the Angiosperms it is absent. Accordingly the study of vascular anatomy in them relates to relatively recent developments. The ancient structural documents have been irretrievably lost.

Similarly, in the fossil record the documents are wanting for the phylesis of Flowering Plants. The outburst of the Angiosperms in the Mesozoic Period has left, so far as we yet know, little trace in the form of fossils with structure. Moreover, such impressions as are found relate commonly to leaves and stems, while flowers and fruits are wanting. The attention commanded by the record of *Cretovarium* by Dr. Marie Stopes (Ann. of Bot. xxiv. p. 679) depended greatly on the rarity of the occurrence of such remains, for it harmonized readily enough with general anticipation. Three other circumstances affect the solution of the phyletic problem of the Angiosperms adversely. The first is the completeness of differentiation of the vegetative and propagative regions, which have diverged under adaptive modification each along its own line. The second is the directness of adaptation of their vegetative system to the environment, which obliterates the archaic, and tends rather to present the recent features. The third is the relatively dead level which these plants have reached in the details of their propagative process. The depressing uniformity of the pollen-sac and of the ovule in Angiosperms leaves little scope for comparative treatment in organs which might otherwise have been full of hope for the morphologist.

Before any general success can be expected in resolving the phylesis of Flowering Plants, so as to establish their main lines of descent, new evidence will be necessary. There will have to be an extension of the *criteria* of comparison. Already there are signs of this in the more accurate comparison of details in the ovule, introduced by Van Tieghem. An intensified search will also have to be made after specimens showing

structural detail from the Mesozoic Rocks. For it was at the period when these were laid down that the immediate ancestors of the Angiosperms flourished.

Methods of enquiry such as these applied to Flowering Plants are equally applicable to other divisions of the Vegetable Kingdom. The cogency of the results will vary with the variety and consecutiveness of the evidence. The *criteria* of comparison will naturally be different. For instance, in the Fungi dependence must be placed on the propagative, rather than the vegetative system, while palæontological evidence is virtually absent. In the Bryophytes, as also in the Algæ, the vegetative system gives greater help than in the Fungi : but again palæontological evidence is lacking. Recent observations, however, point to the existence of sporogonium-like bodies even from the Lower Devonian : thus indicating, on a basis of direct evidence, a higher degree of antiquity than had previously been contemplated.

There remain the Pteridophyta. In them, and particularly in the Filicales, evidence from various sources converges, so as to form a wide basis for their phyletic arrangement. The results may indeed be held as more effective here than in any other large group of Plants. We know from the fossil record that organisms rightly ranked as Ferns date back far into the Palæozoic Period. Such types, with modifications, may be consecutively followed through successive horizons to the Present Day. Comparison shows that some, though relatively few of the Ferns now living, correspond to the archaic types of the Palæozoic ; while those of successively later horizons are represented more and more freely in our present Flora. Finally, the great mass of our living Ferns show characters which stamp them as distinctly modern. Old though the Filical type undoubtedly is, we conclude from inner comparison, as well as from the Fossil Record, that the fullness of its development is that which we see in the majority of the living Ferns of the Present Day. It is not a type which has stood still, but one which has consistently advanced : and the advance has been as definite as that of the Flowering Plants, but along quite different lines. Thus the Filicales offer a singularly instructive field for the application of a phyletic method, so as to elicit a really Natural Classification.

The basis upon which conclusions as to the evolutionary sequence of such a group as the Filicales are to be arrived at, is at root that of the Natural System of Classification, as commonly practised. It depends upon the recognition not of one character or of two, arbitrarily selected as suitable for ready use : but of as many characters as possible, which shall collectively serve as *criteria* for comparison. In respect of each of these, variation will be found as we pass from type to type. Such variations must be seriated, and it will usually appear that they fall between two extremes. The question then arises of the relative age of these extreme types. They may, of course, have resulted from divergence from some middle type, and the enquirer

should always be prepared for this. But usually they bear the relation of one extreme being relatively primitive, and the other relatively advanced. Such a conclusion, based on comparison, should whenever possible be checked by reference to the Fossil Record. Thus with a high degree of certainty that which is archaic may be distinguished from the more modern type, in respect of the character in question.

A good illustration of the effect of the Palæontological check is found in the Filicales in respect of the type of sporangium. Von Goebel, in 1881 (Bot. Zeit. p. 717), distinguished the more massive types of sporangium seen in the Ophioglossaceæ and Marattiaceæ as Eusporangiate; while the more delicate types characteristic of the Polypodiaceæ were styled Leptosporangiate. Both are Filical types. Do they stand to one another as relatively primitive, and relatively advanced? If so, which was the earlier? I had written in 1889 (Ann. of Bot. iii. p. 305) a paper on "The Comparative Examination of the Meristems of Ferns as a phylogenetic study." All their meristems were shown to exhibit a parallelism with the sporangia in point of complexity. So that the difference between the Eusporangiate and the Leptosporangiate is really a difference of organization of the whole plant. Influenced by the general opinion of the time,—itself based on the assumed affinity of the Hymenophyllaceæ to the Mosses,—I then held the simpler Leptosporangiate type of organization to be the more primitive. But here came in the value of the Palæontological check. Stimulated by a paper of Professor Campbell, as cogent as it is brief (Bot. Gaz. vol. xv. Jan. 1890), the question was re-examined in the light of the fossil evidence. The virtual absence of Leptosporangiate Ferns from the Palæozoic, and the prevalence of the Eusporangiates at that period led to the inversion of the series (Ann. of Bot. vol. v. 1891, p. 109)—a position now generally accepted. Sporangial structure, which is an index of a bulky organization and complex segmentation of all the parts in certain types, and of a less bulky and complex construction in others, may accordingly be taken as a criterion. As exemplified by Fern sporangia, the more bulky Eusporangiate type is the more primitive, the less bulky Leptosporangiate type is relatively advanced.

How far this will serve as a real index of their general organization is shown by the comparison between the sporangia and antheridia of the same plants, first instituted by von Goebel. It is found that where the sporangia are large and thick-stalked, or even sunken as in *Ophioglossum*, the antheridia are relatively large and are sunken too; while in the Leptosporangiates, with their smaller sporangia and long stalks, the antheridia are also stalked and relatively small. The comparison even extends, though not with numerical accuracy, to the numbers respectively of spores and of sperms. Where the number of spores per sporangium is large, as in the Eusporangiate Ferns, the spermatozoids are also very numerous in each antheridium: in the

Leptosporangiates, where the spore-numbers are relatively small, the number of sperms is smaller also. Such facts give confidence in the value of this criterion, indicating that the sporangium is a real index of relative complexity of organization, which is thus seen to extend to the gametophyte generation.

In similar ways other criteria have been established. Each has been checked by comparison, and as far as possible according to the fossil evidence. The most important may be tabulated as follows for the Filicales, i.–xiii. relating to the sporophyte, xiv.–xvii. to the gametophyte :—

i. *External form*, the upright radial shoot being relatively primitive, the prone derivative, but with frequent reversions to the upright.

ii. *Cellular segmentation*, the more complex being primitive, and the less complex derivative.

iii. *Dermal appendages*, simple hairs being primitive, and scales derivative.

iv. *Stelar structure*, the protostele being primitive, and successively the medullated protostele, the *Lindsaya*-type, the solenostele, and the dictyostele being derivative. The progression may in certain cases be followed in the ontogeny.

v. *Leaf-trace*, the coherent being primitive, and the divided trace derivative. This may also be followed in the ontogeny.

vi. *Venation*, the open venation being primitive, and the reticulate derivative. With this goes the "webbing" of the leaf to form large laminar areas.

vii. *Soral position*, the marginal being the prevalent primitive type, and the superficial frequently, or perhaps always derivative.

viii. *Soral construction*, the simple simultaneous sorus being primitive, the gradate a frequent middle condition, and the mixed sorus derivative.

ix. *Indusial protections*, none being present in primitive types: various in form in intermediate types : but again indusia are absent in the most advanced.

x. *Sporangial structure*, eusporangiate being primitive, and leptosporangiate derivative.

xi. *Mechanism of dehiscence* : the annulus is indefinite in structure, with median dehiscence in primitive types : oblique and continuous, with lateral dehiscence in intermediate types : vertical and interrupted, with lateral dehiscence in advanced types.

xii. *Spore-output* : large (*i.e.*, typical numbers 128, 256, 512, 1024, &c.) in primitive types : small (*e.g.*, 64, 48, 32, 24, 16, 8, &c.) in derivative types.

xiii. *Character of spore* : the form is not a reliable character, except in

ERRATA IN No. 295.

Heterangiums of the British Coal Measures :—

Page 75.	Foot-note, line 4, at end, for 19 read 13.			
,, 84.	,,	,, 1,	,,	for N. 19 read N. 13.
,, 104.	Line 13, at end, after N, add 13.			

near circles of affinity. The perispore is absent in most primitive types; but it is present in many derivative types.

xiv. *Form of prothallus*: relatively massive in primitive types, relatively delicate in derivative types. But the character is unreliable.

xv. *Sexual organs*: sunken in primitive types, projecting in derivative types.

xvi. *Number of spermatocytes* in each antheridium: large in primitive types, smaller in derivative types.

xvii. *Embryology*: with suspensor present in a few primitive types, but mostly without. The embryo relatively massive with axis vertical in primitive types, more delicate with axis prone in derivative types.

These are the most important criteria for the phyletic seriation of the Filicales. Many others are possible, and those stated raise many side-issues. Their value individually is undeniable; but it is vastly enhanced by the fact that the progression which each criterion shows in its own individual feature runs parallel, as a rule, with progressions in the features of other criteria. For example, Eusporangiate Ferns have a relatively complex cellular segmentation, hairs as dermal appendages, usually an open venation, a simple type of sorus, without indusium, massive sporangia, deeply-seated sexual organs, and an upright embryo, sometimes with a suspensor. The more advanced Leptosporangiate Ferns have a relatively simple cellular constitution, scales as dermal appendages, frequently a reticulate venation, gradate or mixed sorus, often indusiate, small sporangia, exposed sexual organs, and a prone embryo with no suspensor. Such parallelisms of progression in a plurality of criteria may also be traced more or less clearly, and with a high degree of constancy, within nearer circles of affinity.

On the other hand, occasional exceptions occur. Thus *Cheiropleuria*, which is Leptosporangiate, has a protostelic stem with dermal hairs; but its leaf shows an advanced type of reticulation, and an Acrostichoid sorus. The axis in this case has retained its archaic characters, while the leaf has advanced. But the converse is seen in the Marattiaceæ; for in them the typical eusporangiate sorus is retained while the vascular system of the stock is broken up into a complex plexus of reticulated strands. Here the sporophyll remains archaic, while the axis has structurally advanced. A somewhat parallel case is seen in *Ophioglossum* (*Cheiroglossa*) *palmatum*, where also the stock is swollen and sappy, and the stele is disrupted into numerous strands. Such exceptional cases do not negative the method; but they serve to remind us that it is Organic Nature, with all its resources of adaptation, that is being dealt with, not a mere mechanism designed after fixed rules.

This is neither the time, nor the place to describe in detail the results which have followed from this more searching application of the Natural Method of Classification to the Filicales. It must suffice to say that in certain features they coincide with the results of the older Systematists, which were based largely on external features. This is a high testimony to the acuteness of their perception of affinity. But it applies rather to the genera and species than to the larger groups. We have seen how assumed affinities or mere circumstance appear to have determined the arrangement of these in the 'Synopsis Filicum.' There is little evidence of any better method in the arrangement in Engler's 'Natürlichen Pflanzenfamilien.' The Hymenophyllaceæ are there placed first, and then in succession the Cyatheaceæ, Polypodiaceæ, Parkeriaceæ, Matoniaceæ, Gleicheniaceæ, Schizæaceæ, and Osmundaceæ; while the Hydropterideæ are spliced in between these and the Marattiaceæ and Ophioglossaceæ. It is difficult at first sight to trace any method in such a disposition. It may, however, be seen to coincide in the leading features with the views of Prantl. For he regarded the Hymenophyllaceæ as the source of the Leptosporangiates and the Schizæaceæ as the source of the Eusporangiates, these two main phyla being distinct. The arrangement is better in Christ's 'Farnkräuter'; for the Eusporangiates, though placed last, are at least in near relation to other Simplices. But it would be difficult to justify phyletically the juxtaposition of the Hymenophyllaceæ, still placed first of all, with the Acrosticheæ, which immediately follow them. The plain fact is, that up to the end of the 19th Century there was little attempt at a definite method in the disposition of the main groups of Ferns in the Systematic Works. The larger groups were still treated as though they represented types isolated from one another in their Descent. It is true that Prantl (Arb. Königl. Bot. Garten zu Breslau, 1892) represented by a graphic figure his conception of the phyletic relations of the main groups. But that figure shows that he believed his Osmundales (which included the Eusporangiates, together with the Schizæaceæ, Gleicheniaceæ, and Osmundaceæ) to be phyletically distinct from his Pteridales (which included all other Leptosporangiates). The one he traces from the Schizæaceæ; the other from the Hymenophyllaceæ, which his figure suggests as having originated from some common but unknown ancestor. This view is an improvement on the haphazard methods that preceded it. But it breaks the continuity of those lines of descent which are now rapidly assuming clearer definition.

Two channels of recent investigation have materially helped towards that clearer presentment: viz., the pursuit of vascular anatomy in Ferns, living and fossil; and the study of those types which had suffered vicissitudes of classification, as shown by the richness of their synonymy. To the former the main contributions have been those of Russow, Poirault, the Bertrands father and son, Gordon, Boodle, Tansley, Kidston, Jeffrey, Gwynne-

Vaughan, and Lang. These have filled in many of the links in the chain of evidence. They tend to demonstrate a consistent progression in stelar structure of the primitive Ferns, fossil and living. It is found to accord generally with the characters of their fructification, and with stratigraphical sequence. It is true that on purely anatomical grounds, and without due reference to the phyletic position of the Ferns compared, or the cogency of their stratigraphical sequence, objection had been taken by the Harvard School to certain well-founded conclusions. But this serves mainly as a warning against reasoning based, as theirs has been, upon a single line of evidence, pursued without due consideration of others.

The second method of investigation is by the enquiry into those Ferns which bear many synonyms, and have obviously been difficult of classification under less searching methods. They now stand revealed as missing links in the phyletic chain. Their being such explains the difficulty they had presented to the early Systematists. As examples, *Lophosoria*, *Metaxya*, and *Cheiropleuria* may be quoted. Each of them had been merged by Sir William Hooker, in consequence of his aversion to anatomical evidence, into other large comprehensive genera. But they have since been re-established as substantive genera. *Lophosoria* links the Gleicheniaceæ with the Cyatheæ; *Metaxya* helps to connect the Gleicheniaceæ with *Elaphoglossum*; while *Cheiropleuria* indicates how, from a type like the Dipterids, a number of later forms may have sprung—and in particular that strange genus, *Platycerium*. Another most important connecting type is *Loxsoma*, and probably also the little-known Costa-Rican Fern, *Loxsomopsis*, which indicate a transition from the Schizæaceæ to the Dicksonioid Ferns. But we need not here attempt to exhaust the list of such connecting types. It is merely intended to indicate how their recognition serves to link up those sequences which form the lower branches of a phyletic system of the Filicales.

An intensive study of large genera is another line which has been pursued with success. For instance, the examination of many species of *Blechnum* has disclosed how that genus, springing from some Matteuccioid source, formed its characteristic fusion-sorus. This then spread over the leaf-surface to form the Acrostichoid developments of *Brainea* and *Stenochlæna*: or it broke up into short lengths, as in *Woodwardia* and *Doodya*; or, if these were displaced by surface-growth, the result appears in the characteristic features of *Scolopendrium* and *Asplenium*. These are quoted as instances of the methods now being pursued in the phylesis of Ferns, and of the results which have followed.

A consequence of the more firm establishment of a number of distinct phyletic lines has been to show more distinctly than before the falseness of certain old-established genera, practically convenient as these may have been. *Polypodium*, *Acrostichum*, and *Gymnogramme*, in the old comprehensive sense, are all doomed to dissolution. They are not genera in the phyletic

sense, but states or conditions, which appear to have been arrived at along a plurality of lines of evolution. This had long ago been recognized in the case of *Phegopteris*, which is Polypodioid merely by abortion of the Dryopterid indusium: it is quite distinct racially from *Eupolypodium*, *Niphobolus*, or *Phymatodes*, in which there is reason to believe that no indusium ever existed. It thus seems probable that the Polypodioid state may have arrived along a plurality of distinct lines. The same is the case with the Acrostichoid state. All that now remains of the genus *Acrostichum*, according to Christensen's Index, are *A. aureum* and *præstantissimum*. And these are now seen to be derived from *Pteris*. Other Acrostichoid Ferns have arrived from some five other phyletic sources. Though the matter is not yet worked out in detail, it may be confidently asserted that the large congeries of Ferns styled *Gymnogramme* had also a plural phyletic origin, some of the species being originally destitute of indusium; others, such as *G. Pozoi*, being destitute of indusium by abortion. The species named is clearly a non-indusiate *Asplenium*, as is also the genus *Aspleniopsis* Mett.

New attempts to group the Filicales phyletically have thus resulted in the recognition of a number of lines, divergent, parallel, or convergent, all starting from Eusporangiate sources. These were characterized by having a simple sorus, consisting of few sporangia, or even of a single one. There is reason to believe that the position of that sorus was in the first instance marginal. That is its position in the Botryopterids, the Ophioglossaceæ, the Schizæaceæ, and *Osmunda*, all very primitive types. In others, as in the Marattiaceæ, the Gleicheniaceæ, and *Todea*, the position is superficial. But in several lines of descent, notably among the derivatives from the Schizæaceæ, a transition from the marginal to the superficial by gradual steps can be traced. And it seems probable that such a transition is accountable for the origin of a superficial position in the other types also. But in them it was carried out at an earlier period in Descent. We may designate the first collectively as the "*Marginales*," and the latter as the "*Superficiales*." This may be recognized as a broad phyletic distinction, dividing the later Filicales into two, for the most part easily distinguished sequences. But our working hypothesis will be that this distinction does not mark an absolute difference: it is only a difference of degree in respect of the *time* of the transition of the sorus from the margin to the surface. But since the soral position is as a rule constant in the species or the individual, the distinction is reliable as a basis for phyletic segregation.

Each of the two main phyla thus distinguished includes a number of subsidiary phyla. Of the *Superficiales* the Marattiaceæ probably ended blind, except for their relation to the Cycadales. The Gleicheniaceæ probably led on the one hand to the Cyatheoid and Nephrodioid Ferns, and finally to their Polypodioid and Achrostichoid derivatives, such as

the Oak and Beech Ferns, or *Polybotrya osmundacea.* A side branch from *Matteuccia* led to *Blechnum*, with *Scolopendrium* and *Asplenium* as further derivatives: also to Acrostichoid types, such as *Stenochlæna* and *Brainea.* A second related sequence starting from *Matonia*, led through Dipterid types to the Acrostichoid state of *Cheiropleuria*, *Gymnopteris*, and *Platycerium.* A third line is indicated by *Metaxya* and *Syngramme*, leading to the Acrostichoid genus *Elaphoglossum.*

On the other hand, from the Schizæaceæ, which are the most important central stock of the living *Marginales*, we may trace the Dicksonioid-Davallioid Series, culminating in Polypodioid forms, such as *P. punctatum.* A side branch indicated by *Lindsaya*, *Pæsia*, and *Pteris*, culminates in *Acrostichum aureum*; while a collateral line probably leads from *Mohria* and *Cheilanthes* to such types as *Hemionitis*, and to the fully Acrostichoid state of *Trismeria.*

From such seriations the fact of parallel development, or *Homoplasy*, as it has been well designated in one of the earliest papers of Lankester, emerges clearly. It is seen not in one case, nor yet in a single feature, but in many. A few examples may be quoted. The dendroid habit is characteristic of the Cyatheaceæ and the Dicksonieæ, two families which were merged by earlier writers, chiefly on the ground of habit. Both have sprung from a creeping ancestry. But the Cyatheaceæ have superficial sori and chaffy scales; the Dicksonieæ have marginal sori and dermal hairs. They represent distinct phyletic lines, the former being of Gleichenioid origin, the latter of Schizæoid descent. Yet they appear so similar in habit that detailed examination is necessary to distinguish them. They exemplify a parallel or homoplastic origin of the dendroid state. Again, dermal appendages illustrate in many distinct sequences the progression from simple hairs which are primitive, to scales which are advanced. The anatomical progression from protostely, to solenostely and dictyostely, as also to polycycly, is illustrated in a plurality of lines phyletically distinct. Soral characters show parallel progressions in many ways. The origin of the gradate and mixed conditions of the sori: the progressive reduction of the spore-output: the swinging of the oblique annulus to the vertical position: the change from median to lateral dehiscence: the protection of the sorus by those heterogeneous growths called indusia, of which there are some half-dozen distinct types: the loss of such indusia, giving the "Polypodioid" state: the spread of the sori to give the "Acrostichoid" condition:—these and many other progressive changes can be shown to have originated along a plurality of phyletic lines; and they have resulted in some cases in so high a degree of similarity that the segregation of the forms showing them according to descent is difficult, however certain it may actually be.

Thus the fact becomes clear as we proceed along the lines of phyletic progress demonstrated by the comparative study of the Filicales, that

parallel development, and even convergence of characters are common phenomena. They may be traced in respect of almost all of the characters, as having been carried out in sequences that must have been phyletically distinct. It is possible, and with some degree of probability, to correlate certain of these changes with the external circumstances. For instance, in the Palæozoic Period forest shade was either absent or imperfect. The robust constitution of the Eusporangiate Ferns suited such conditions well enough. The great outburst of the more delicate Leptosporangiate Ferns took place in the Mesozoic Period, and doubtless the advent then of broad-leaved trees, with their more effective shade, permitted plants like these, of less robust habit, to flourish. At the same time many of them, through their self-protection by dermal scales and indusial growths, had become more independent. A curious biological feature becomes, however, evident in their further advance. For along many separate but parallel lines their indusial coverings have become aborted in the species of the present day, and the sori fully exposed again. It is as though the organisms had themselves become in some way more resistant to exposure. For such present-day plants often occupy exposed stations. This is the case in our own *Polypodium alpestre*, properly called by Newman *Pseudathyrium*; also in the Oak Fern and Beech Fern. All of these may be found on hill stations, though they have exposed sori. This condition is due to the abortion of indusia, in the first case of the type of *Athyrium*, in the latter of *Dryopteris*.

It is not only parallelism of development, however, but even convergence which is frequently seen. A good example is provided by the genera *Cystopteris* and *Acrophorus*, which have been notoriously difficult to place. They are ranked sometimes with the Davallioid, sometimes with the Nephrodioid Ferns, two quite distinct phyla. So far as their venation or their sori go, they might belong to either. But their anatomy, and the presence of the characteristic chaffy scales, proves them to be of Nephrodioid affinity. Another case is that of *Doryopteris*, long ranked with *Pteris*, with which its fusion-sorus is in close agreement. But it was separated by Prantl on more general grounds, and ranked, probably correctly, with *Pellæa* and the Cheilanthinæ. Other examples are the Davallioid genera *Nephrolepis* and *Oleandra*, which curiously mimic the Nephrodioid sorus, though of quite a different origin from it. Thus convergence of characters is a recurrent feature in the Filicales. There is, indeed, no group of highly organized plants which shows more frequently, and indeed consistently, evidence of parallel or convergent progressions in distinct phyletic lines; while the parallelisms and convergences involve a great variety of characters, both vegetative and propagative. I commend such facts to evolutionary theorists as a pressing problem for them.

The question will be, what causes have been at work to produce such results? They are usually set down to the selection of favourable divergences from type out of inheritable variations, or mutations, produced

at random. But the prevalence of parallel development and convergence suggests that they are not produced at random. Possibly such progressions may be directed by some internal or physiological necessity. They raise, however, in my mind very forcibly the question whether or not these changes are promoted, or actually determined in their direction, or their number, or their quality, in some way by the external conditions. I am not aware of any facts which would raise this beyond the level of reasonable suggestion, or probability. It is far from being proved; but it is equally far from being disproved. It is in fact an open question. Until the contrary is proved it would, in my opinion, be wiser to entertain as a working hypothesis some such view as that suggested than positively to deny it. The impress of external circumstance cannot properly be ruled out in the genesis of inheritable characters simply because up to the present time no definite case of inheritance of observable characters acquired in the individual lifetime has been demonstrated. Already evidence is available from the side of Zoology which, though it may not yet amount to demonstration, makes the negation of inheritance of acquired characters perilous. A single positive observation may at a stroke upset the whole negative position. Moreover, the prevalence of parallel and convergent characters has made that position suspect to many of those who pursue Morphology, whether of the animal or of the vegetable kingdom. More especially I have found that this doubt is entertained by those who have lived in the atmosphere of experiment and observation found in large Botanic Gardens.

Plants would seem to be particularly favourable subjects for observation in testing this question. The early segregation of the germ-cells in the animal body was a fact which weighed greatly with Weismann in his negation of the inheritance of acquired characters. But in Plants that early segregation does not take place. In them the tissues, undifferentiated as somatic and germ-cells, are for long exposed to the conditions under which vegetation is carried out, before the germ-cells are specialized. When this circumstance is given its full weight, such results of comparison as we have been discussing seem to me more intelligible if related causally in some way with the external conditions under which evolution proceeds, than if that be denied.

There are various ways of approaching the problem, such as the comparative, the experimental, and the line of Mendelian analysis. Those who approach the facts by the last should keep an observant eye also on the methods and the conclusions of those who use a different method of enquiry. More particularly they should watch with sympathetic interest those who pursue the morphological avenue of approach to final truth: and especially when these observers are by pursuit of that avenue led to conclusions divergent from their own. Many Morphologists have found themselves unable to accept that general application of the theory of "inhibiting

elements" put forward, as accounting for progressive evolution, by Bateson in his Presidential address to the British Association in Australia. To me the process of Mendelian Segregation appears to be nothing more than a distributing agency. It constructs nothing: nor does it originate new morphological characters. We have to look elsewhere than to Mendelian Segregation for the origin of those structural innovations upon which progressive Evolution depends. The chief interest of Evolution lies in this initiation of new structural characters, rather than in the distributing agency to which they are subject. The obvious relation of their cumulative result to the environment, which we recognize as adaptation, carries with it homoplasy, or even convergent development in lines phyletically distinct. This is seen in high degree in the Filicales. It suggests, as the most probable interpretation of the facts, that some causal connection exists between the environment and those innovations which are the mark of structural progress.

It has been impossible in this Lecture to do more than to give a slight sketch of the methods recently employed in elucidating the phylesis of the Filicales. Any more explicit statement of the results arrived at must be reserved for some other occasion. Meanwhile such results have been used as an illustration of the modern method of Natural Classification. I hope what has been said may suffice to show that real progress is being made. Such measure of success in natural grouping as has been achieved among the Filicales may serve to stimulate like efforts directed to other groups of Plants. But it is useless to expect success to be as ready to hand in them as in the Filicales. These plants present an exceptionally favourable opportunity, owing to the nature of the evidence available. The Angiosperms offer a still wider field; but it suffers from deficiencies of evidence, which have already been explained. Moreover, the variety and extent of their special adaptations complicate the problem, and often tend to disguise the natural affinities. Still, it is not a hopeless quest to do the same for them. But what is urgently needed for success amid the multiplicity of their lines of progress is a widening of the bases of comparison. There must be a recognition of new criteria. A revision of the relative values of the old criteria will also be necessary. These innovations, together with the more free discovery of fossils with structure from the Mesozoic Rocks, would provide the lines along which opinion may be expected to develop. It is with this hope that I have used the Filicales as an object-lesson in this Address. For the method which is being successfully applied to them may be confidently expected, sooner or later, to unravel even the tangled skein of Angiospermic Descent. Eventually it may lead to some more satisfactory, and assured arrangement of them according to Descent than has yet been achieved.

Two Critical Plants of the Greek Flora.

By C. C. Lacaita, F.L.S.

[Read 3rd May, 1917.]

(1) Thymus Sibthorpii, *Benth.* = T. lanceolatus, *Sibth. & Sm. non Desf.* = T. heterotrichus, *Griseb.*

The above synonymy was proposed by Čelakovský in 1882, but as neither he, nor any other author who quotes these names, except Bentham, ever saw the unique specimen in herb. Sibthorp at Oxford, which lies before me as I write, it may be useful to confirm Čelakovský's opinion with the aid of that specimen, on which alone Bentham, Gen. & Sp. Lab. p. 345 (April 1834), based his *Thymus Sibthorpii*.

There is nothing with the specimen to indicate where it was collected by Sibthorp. The ticket on the sheet only bears the words "*Thymus lanceolatus Desfont. Atlant.* t. 128" in the handwriting of Smith, who in Fl. Gr. Prodr. p. 419 (1806) merely quotes "*T. lanceolatus Desf. In montosis Græciæ.*" Bentham at first rightly distinguished this *Thymus* from *T. lanceolatus*, Desf. of Algeria as being "*foliis glabris, rigidis, nec ut in T. lanceolato molliter villosis.*" There are indeed stronger reasons for the separation, the chief of which I summarise as follows :—*T. Sibthorpii* differt a *T. lanceolato* foliis floralibus non dilatatis, spicastro graciliori, minus compacto, calyce triplo minore, omnino alienis, et corolla multo minore.

The Algerian specimens on which I rely for these distinctions are: (1) Jamin, Pl. Alger. 1851, no. 201; (2) Bové, no. 254; (3) Munby from Sidi Ben Abbas, all of which can be seen in Herb. Kew.

In 1844 Grisebach, Spic. Fl. Rum. ii. p. 116, described very fully a plant from Mount Athos to which he gave the name of *T. heterotrichus*, attempting to distinguish it from *T. Sibthorpii* only because the latter has "folia latiora glabra et corollam vix calycem excedentem." It is, nevertheless, undoubtedly identical with *T. Sibthorpii*. Unfortunately, when Bentham returned to the thymes in DeCandolle's 'Prodromus,' he confused under the name of *T. lanceolatus*, Desf. three totally distinct plants, viz.: the true *T. lanceolatus* of Algeria, a Persian species *T. lancifolius*, Čelak., and his own *T. Sibthorpii*, but at the same time he separated *T. heterotrichus*, Griseb., although with the remark "An idem ac *T. lanceolatus?*"; see DC. Prodr. xii. pp. 199 and 203 (1848). It is to be remembered that Grisebach never saw Sibthorp's specimen, nor had Bentham seen Grisebach's.

Boissier, 'Flora Orientalis,' iv. p. 555 (1879), wrongly identified both *T. Sibthorpii* and *T. heterotrichus* with *T. Serpyllum* var. *Chaubardi* (*T. Chaubardi*, Boiss. & Heldr. pl. exsicc. 1851, no. 269 = *T. glabratus*, Bory & Chaub.

non Hoffmg. & Link = *T. angustifolius* var. *Chaubardi*, Boiss. & Heldr. Diagn. ser. 2, iv p. 6 (1859) = *T. Serpyllum* var. *Chaubardi*, Boiss. Fl. Or. l. c.), which is the common representative of the *Chamædrys* forms of *T. Serpyllum* all over Greece, and also occurs in profusion in the mountains of South-Western Italy. But in a MS. note posthumously published in Fl. Or. Suppl. p. 359 (1888) Boissier, in deference to Čelakovský's opinion, separates *T. Chaubardi*, "*T. Chamædryi* nimis affinis," from *T. heterotrichus*, Griseb., identified with *T. lanceolatus*, Sm. and *T. Sibthorpii*, Benth., which is "ab omnibus *T. Serpylli* formis plane diversus." For in the meanwhile Čelakovský, the most clear-sighted observer in this genus and one not disposed to overrate lesser variations, had put the matter right in Flora, xl. (1882) pp. 146 and 172, on the strength of specimens collected on Mount Athos by Janka and by Pichler, identifying *T. heterotrichus* with *T. Sibthorpii*, whilst clearly distinguishing *T. Chaubardi*. He does not appear to have seen Grisebach's type, but the precise locality ensures Janka's and Pichler's specimens being identical with it. On the other hand, he had certainly not seen Sibthorp's specimen for which no precise locality is assigned, but it is known that Sibthorp visited Mount Athos. His herbarium contains many plants from that mountain. I have compared his type with Pichler's Athos plant, which I have examined in Herb. Kew and in an example generously lent for inspection by the conservator of Herb. Boissier, and feel quite certain of their identity. Pichler's plant was collected in August 1873. The tickets of the two Kew examples read (*a*) "Macedonia, in sylvis Montis Athos, Aug. 1873," (*b*) "Macedonien, Auf Pergen (*sc. Bergen*) am M. Athos bei Charies. Aug. 1873," and that of Herb. Boiss. "Th. *Sibthorpii*, no. 183, Auf dem nordlichem Abhange des Monte Santo." Janka's specimens I have not seen, but there is a plant in Herb. Boiss. from Constantinople, leg. Coumary, under the name of *T. montanus*, Waldst. & Kit., which is certainly *T. Sibthorpii*, though the leaves are rather broader and more obtuse.

Velenovský, Fl. Bulg. p. 469 (1891) and in his Nachtrag of 1903, p. 15, describes *T. heterotrichus*, Griseb. at some length, asserting that it is plentiful in Macedonia on the Konjovo Planina and Osgovska Planina, at Krapec and above Rilo Selo; "planta in M. Atho a cl. Janka lecta eadem est ac nostra." In the Nachtrag he says "in Bulgaria valde frequens" and creates a subspecies *cinerascens*, "planta eximia sed transit in typum," for which he quotes five Bulgarian localities. But he does not allude to the identity with *T. Sibthorpii*, although his Flora was published nearly ten years after Čelakovský's work. It is also surprising that Halácsy in his 'Conspectus Floræ Græcæ,' ii. p. 563 (1902) should have repeated the erroneous identification of *T. Sibthorpii* with *T. Chaubardi*; on p. 565 he alludes to *T. heterotrichus*, Griseb. as "species ab autoribus varie interpretata, mihi ignota."

I have not seen specimens of *T. heterotrichus* from the habitats enumerated

by Velenovský, or from the Greek localities cited by Formanek in Verhandl. Brünn, 1896, p. 67 and 1897, p. 50, but several plants collected by Haussknecht in Western Greece in 1885 (specimens in hb. Kew) and distributed as *T. Sibthorpii* var. *grandiflorus* and var. *subalpinus* are certainly not forms of *T. Sibthorpii*, perhaps not even of *T. Chaubardi*. All that concerns the present argument is the identity of the Athos plant on which Grisebach's species rests with Sibthorp's specimen. That identity being firmly established cannot be shaken by possibly incorrect determinations of plants from other regions.

It only remains to consider possible objections to this identification on the ground of discrepancies in the descriptions or superficial differences in the specimens. I will deal with those that occur to me.

(1) Pichler's specimens were gathered in August and are in full bloom; Sibthorp's has almost ceased flowering. Consequently the lower leaves have fallen, only those of the upper part of the stem remaining, and the plant shows what Čelakovský, before he knew Pichler's specimens, described from Janka's "gathered long after flowering with dried-up racemes and fallen bracts," viz., "in the leaf axils of the sterile stems as well as in the middle of the flowering ones there are formed characteristic short sterile branches with, at the end of the branch, compact bunches of leaves that are half as long as the supporting leaves but of the same shape." In Pichler's specimens these are not yet developed.

(2) Another consequence of late gathering is that the corollas appear even smaller than when gathered by Pichler in full bloom. Bentham says "corolla vix calycem excedens"—Grisebach, "corolla calyce sesquilongior" (his main reason for separating his species from Bentham's), but Velenovský, "corolla vix exserta." In fact calyx and corolla together are very small—half the size that those of *T. Chaubardi* usually attain. As far as I can measure on herbarium specimens the calyx, including teeth, is only 3–4 mm. long and the corolla, though clearly "exserta," is less than "sesquilongior."

(3) The leaves both in Sibthorp's and Pichler's plants are flat, "plana" as described by Grisebach, not "margine revoluto" as stated by Velenovský. Pichler's measure 20 by 6 mm.; Sibthorp's 15 by 5 mm. The middle and upper stem-leaves are narrowly elliptic *, *i. e.* tapering almost equally at both ends, but the lower leaves are obovate or obovato-spathulate. Grisebach calls them "lineari-lanceolata versus basin attenuata"; Velenovský says "ovato-oblongis, oblongisve et lineari-oblongis," which will cover a multitude of sins, including those of Coumary's specimen which are about

* This botanical use of the word elliptic is of course mathematically incorrect. The figure bounded by two intersecting menisci is not an ellipse. Bentham describes these leaves as "oblongo-lanceolata" which is certainly incorrect. An oblong has not curved sides and a lance is broader towards the base than towards the point.

13 by 7 mm. The only real discrepancy is in the "marginè revolutis" of Velenovský, and he was not describing Athos specimens.

(4) Bentham says "suffrutex semipedalis," but of the pieces on Sibthorp's sheet two measure just 8 inches (20·5 cm.); Pichler's and Coumary's plants 10–22 inches without the base of the stem. Grisebach places *T. heterotrichus* among his "fruticuli erecti vel ascendentes, rhizomate descendente," distinguished from "suffrutices, ramis primariis demum decumbentibus, floriferis adscendentibus." Indeed, the whole plant is obviously a much taller and more erect plant than *T. Chaubardi* or any of our forms of *T. ovatus* (*T. Chamædrys*).

(5) The rather stiffly hairy calyx is set, as in so many Mediterranean thymes, with beautiful ruby glands, some of which also stud the outside of the corolla. Hitherto no one seems to have noticed that a certain number of similar glands are found on the upper part of the stem itself. These are conspicuous in Pichler's and Coumary's plants, but are very difficult to see on Sibthorp's. However, I have detected a few.

The *Thymus* to which this species seems more nearly related by its remarkably small calyx and corolla is *T. montanus*, Waldst. & Kit., as figured in Pl. Rar. Hung. t. 71, and represented Fl. Exsicc. Austr. Hung. no. 2142 and by the Slavonian specimens from Mt. Veliky Gradac, distributed by Dr. S. Kupcok. This, however, has the leaves of *T. ovatus* (= *T. Chamædrys*), glabrous stems and calyces hardly, if at all, glandular. But it would require a complete study of the thymes of the Balkan peninsula to establish the precise affinities and the limits of distribution of *Thymus Sibthorpii*.

(2) Crepis rutilans, sp. nov., e Sect. *Barkhausia*. Radix verticalis, nescio an biennis seu annua. Caulis solitarius, erectus, 35–65 cm. altus, villis albis, mollibus, tenuibus et pilis robustioribus rubro-purpureis, basi dilatato insidentibus, præditus. Folia pilosa, mollia, inferiora in exemplari (A) simplicia, leviter repando-dentata, dentibus retrorsis, in (B) runcinato-pinnatopartita segmento terminali maximo; caulina media amplexicaulia, oblonga, superiora e basi sagittata lanceolata. Pedunculi etiam ante anthesin erecti, sub anthesi breves (1–2·5 cm.), in fructu elongati (1·5–3 cm.), pilis rubro-purpureis aliisque pallidis brevioribus, nonnullis glanduliferis, crebre vestiti. Capitula mediocria, eis *C. setosæ* æqualia, illis *C. fœtidæ* dimidio minora. Involucri phylla externa subadpressa, pilis longis rubro-purpureis barbata, interiora sparse cano-tomentosa, dorso etiam in fructu vix indurato. Achenia tenuia, omnia in rostrum tenuissimum, ipsis vix brevius, abeuntia, pappo niveo involucrum vix superante.

Differt ab omnibus *C. fœtidæ* varietatibus caule non a medio ramoso, panicula corymbosa, alabastris erectis, capitulis minoribus, acheniis cum pappo duplo brevioribus.

A *Crepidi setoso,* cui structura affinior, indumento molli pilisque rubro-purpureis.

Cæteris *Crepidibus* in Græcia aut Italia notis omnino absimilis, insigni charactere, pilis rutilis, statim dignoscitur.

The above account is based on the only two specimens of whose existence I am aware : (A) A plant in seed in John Ball's herbarium, now at Kew, left by him without any name but now bearing the words "*Crepis* (*Barkhausia*)" in the hand of Mr. J. G. Baker. Ball's label reads "Iter orientale 1877. Ex Insula Corcyra in maritimis. Mense Junio. J. Ball." (B) A plant, hardly yet in full bloom, in the herbarium of Mr. G. C. Druce, collected by him at Monrepos, Corfu, in May 1914.

It is with some hesitation that I have ventured to propose a new species based on only two specimens, but I am encouraged to do so in the hope that botanists who visit Corfu will look out for this remarkable plant and make plentiful gatherings of it.

March 18th, 1917.

A Systematic Study of the North American Melanthaceæ from the Genetic Standpoint.

By R. RUGGLES GATES, Ph.D., F.L.S.

(With MAP (Plate 5) and 1 text-figure.)

[Read 15th March, 1917.]

INTRODUCTION.

THE purpose of the present paper is a little different from that of any previous publication, so far as the writer is aware. It aims to furnish the application to a particular group of plants of a definite point of view regarding the genesis of species. It may be said that every systematist has a point of view in his work, and this is doubtless true, the point of view having been furnished largely by the general Darwinian background, which assumes the gradual and infinitesimal differentiation of species.

The point of view of the present work is essentially different, in that it assumes the variations which differentiate species not to have been universally continuous and infinitesimal, but to have been definite and often discontinuous. To the writer, one of the most important advances since Darwin has been in the discovery of the *definiteness* * of variation. This knowledge is based upon experimental results obtained largely through the work of De Vries, Bateson, Baur, Nilsson-Ehle, and many others during the last fifteen years. The writer has endeavoured to analyze this definiteness in the case of the *Œnothera* mutations, and has reached the conclusion † that many different though definite types of change are involved, each giving rise to a different and characteristic mutation. The essential conceptions of variation thus developed through long experience and experiment by the writer with the Œnotheras are here applied to the specific and generic differentiation of a group of Liliales which has not been made the subject of experiment. In short, the method is to apply the mutation conceptions to the systematic treatment of this Liliaceous group in order to determine in how far the method is valid and useful. It cannot be expected that final conclusions will be reached in the absence of experimental analysis, and yet I believe the method is sufficiently illuminating to justify its adoption and application to other groups. On the other hand, it must obviously be used with caution, and in such a way that speculation does not too far outrun verification by means of cytological studies and breeding experiments. If, however, the

* By definiteness of variation I mean not necessarily orthogenetic variation, but marked and clearly defined variations which may occur in any direction or in many directions simultaneously.

† 'The Mutation Factor in Evolution,' p. 353. Macmillans, London, 1915.

general conceptions of definiteness and discontinuity in variation are sound, then the principles that arise from these conceptions should serve as a touchstone when applied to the study of the origin and relationships of living species. The present work is published as an example of what may be accomplished in this direction. It will doubtless be criticized from many points of view, but it is hoped that as a first step it will not be entirely without justification.

This work is the outcome of a study which began with several pairs of species *, taken at random as regards their distribution, differences, and probable manner of origin. The group Melanthaceæ was selected on account of its compactness and because it is far removed from the Onagraceæ. The conceptions here applied to these families will doubtless apply equally well to many others. That variations are often marked and definite, who will now deny? It is with the hope of convincing systematic workers that these conceptions are not only useful but necessary, if we are to reach an understanding of specific differences, that this publication is undertaken. The definite conceptions of germinal variation or mutation, which are founded on careful analytical, experimental, and cytological work, need to be incorporated into the biological thinking of the time, and this can only be done by applying the results of experiment to groups where experiment has not taken or cannot take place.

On the other hand, it soon becomes clear that, while many variations have been sharp and definite, this is by no means universally the case. The continuous and indefinite variations which sometimes lead from species to species are the difficult ones to analyze. It may be admitted that their evolutionary significance is at present insufficiently analyzed and practically unknown, despite the current assumption that "fluctuations" are not inherited and are therefore not of evolutionary value. The present paper, while pointing out frequent cases of such "continuous variation," is equally concerned with the cases of discontinuity. Many of the latter are obviously due to gaps caused by extinction, but many more are undoubtedly the result of discontinuous or definite variations. Is it, for instance, probable that a verticillate arrangement of the leaves, as in certain species of *Polygonatum*, in the related family Convallariaceæ, arose gradually from an arrangement opposite, in pairs? And, again, is it not more reasonable to assume that the "knee" in the peduncle of *Streptopus* arose as a definite and marked variation, than that it was slowly and gradually evolved? It appears that in many cases differences which are now used as generic characters originated by a marked and definite step. The argument that extinction accounts for their present distinctness is certainly often excluded.

Moreover, the mere fact that related genera showing marked differences

* "On Pairs of Species," Bot. Gazette, lxi. 1916, pp. 177–212, figs. 12.

in structural characteristics often co-exist side by side * indicates that these differences were probably not of selective value, but they arose through what Darwin called "spontaneous variation," and have been perpetuated by heredity. It is thus believed that, while natural selection accounts for the gradual development of adaptations through the accumulation of larger or smaller variations, the mutation theory accounts for the origin of innumerable generic and specific differences which were never of selective value to their possessor. In the years when natural selection was the only accepted factor of evolution, it always required a large measure of credulity to believe that every character of every organism had been at some time of particular value to its possessor. The mutation theory renders unnecessary such an assumption, and thus relieves natural selection of the necessity of explaining too much.

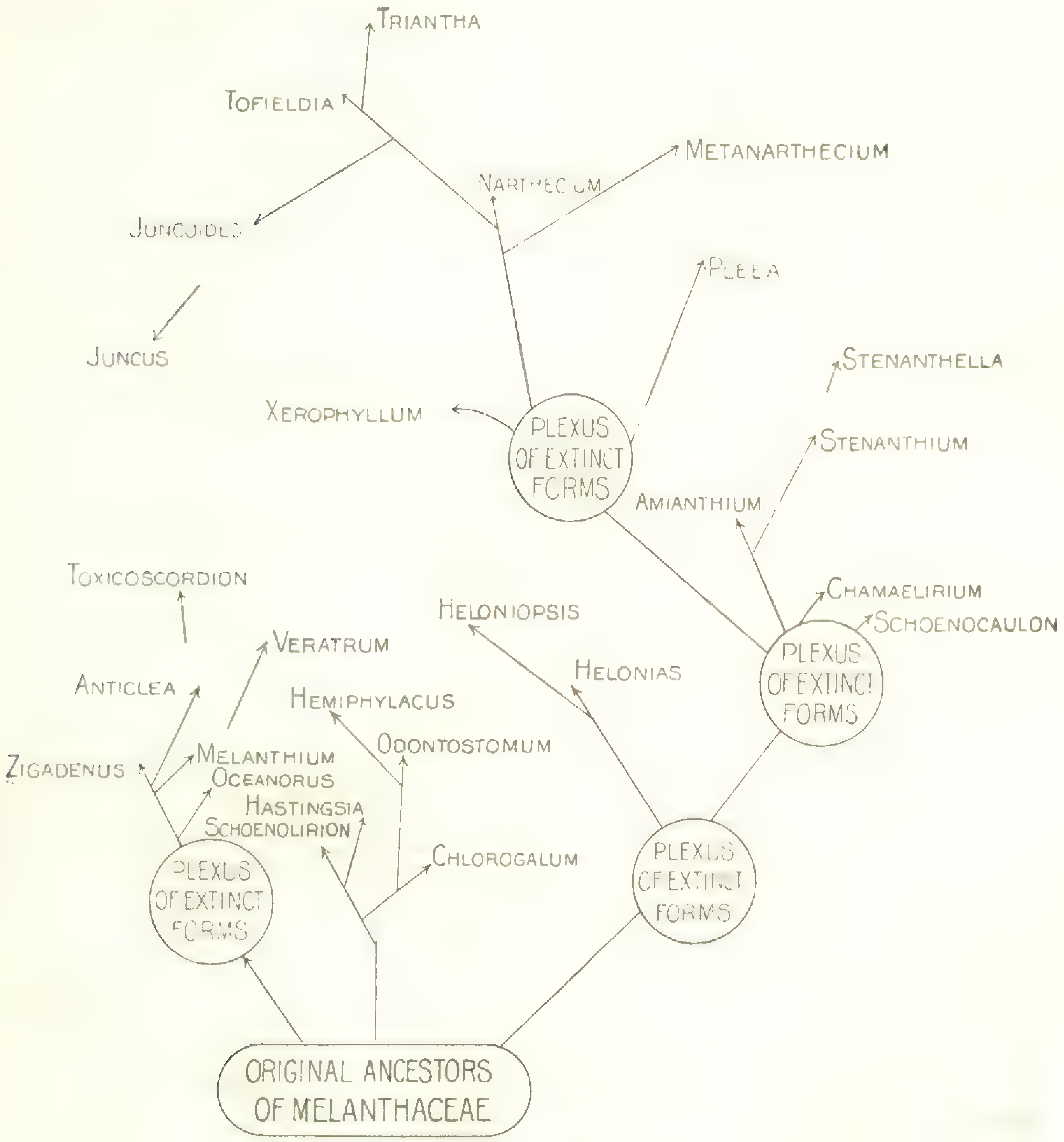
With these and similar conceptions in mind, the North American Melanthaceæ have been studied systematically. The result is incomplete, because some of these genera are still insufficiently known, and I have not had an unlimited time to devote to the subject. It is hoped that the work will be most useful for its suggestiveness. We know that many variations are marked steps, and that such variations are inherited, while we as yet know very little of the inheritance of continuous variations, and what is known is largely negative in character. If systematists are to reflect the knowledge of their time in the construction of their species, then obviously they need to pay at least as great attention to discontinuous as to continuous variability, our knowledge of the former being firmly based on experiment.

The analyses of specific and generic differences attempted in this paper may appear speculative, but at least they are no more so than they would be if they assumed variation to be continuous. They, moreover, have the definite advantage of being based on analogy—sometimes direct analogy—with known experimental results. It is hoped that the explanations here suggested of various specific and generic relationships will lead to the further study of many of these species both cytologically and experimentally, for this is the only way in which the questions here propounded can be definitely solved. It would be an attractive problem to make a comparative study of the chromosomes throughout the group, and it is hoped that botanists will avail themselves of this opportunity whenever they can obtain the necessary material.

In the systematic treatment of these groups it has been necessary to describe several new species and varieties and to make several new combinations, though an effort has been made to circumscribe their number. It is perhaps doubtful whether the segregation from *Zigadenus* of the genera *Toxicoscordion*, *Anticlea*, and particularly *Oceanorus* should be recognized, though I have here given them the benefit of the doubt. It is easily

* *Cf.* Gates, R. R., "The Mutation Theory and the species-concept," in Amer. Nat., Oct. 1917.

possible to carry the process of subdivision of existing genera too far, and by so doing to destroy the usefulness of the genus and impair its definiteness as well. It seems certain that no new genera should ever be introduced in the groups here under consideration. The indiscriminate creation of new



Phylogeny of Melanthaceæ.

generic names obscures relationships, and there is nothing to be said in its favour.

In the citation of specimens in this paper it is to be assumed that all specimens are from the Herbarium of the Missouri Botanical Garden, unless otherwise specified. I am greatly indebted to Dr. Geo. T. Moore, Director of the Missouri Botanical Garden, for placing the facilities of the institution

at my disposal, and to Dr. J. M. Greenman for frequent consultations in connection with the systematic work. Mr. C. H. Thompson has kindly taken a number of photographs. At the University of California, through the kindness of Dr. W. A. Setchell and Dr. H. M. Hall, I was able to study the large collections of Californian Liliaceæ, and I am also indebted to Dr. Setchell for a fine series of photographs of herbarium specimens.

1. TOFIELDIA, Huds.

1. TOFIELDIA PALUSTRIS, Huds. Fl. Angl. ed. 2, 157 (1778); Delar. in Redouté, Lil. v. t. 256 (1809)*.

T. pusilla, Willd. in Mag. Gesells. Naturf. Fr. ii. (1808) 27.
T. borealis, Wahlenb. Fl. Lapp. (1812) 89.
Narthecium boreale, Wahlenb. in Nov. Act. Holm. xxvi. (1803) 24.
N. alpinum, Michx. Fl. Bor. Am. i. (1803) 209.
N. pusillum, Michx. *l. c.*
Anthericum calyculatum, β, Linn. Fl. Suec. ed. 2 (1755), 108.

Greenland and Labrador to Alaska, south to Quebec, Lake Superior, and the Canadian Rockies. Also in Europe and Northern Asia.

2. TOFIELDIA CALYCULATA, Wahlenb. Veg. Helv. (1813) 68.

Anthericum calyculatum, Linn. Sp. Pl. (1753) 311; Fl. Dan. (1766) t. 36; Linn. Fl. Lapp. (1792) 106, t. 10. f. 3; Smith, Engl. Bot. (1799) t. 536.
Scheuchzeria Pseud-Asphodelus, Scop. Fl. Carn. i. (1772) 263.
Narthecium calyculatum, All. Fl. Pedem. ii. (1785) 165; Lam. Encyc. iv. (1823) t. 268.
Helonias borealis, Willd. Sp. Pl. ii. (1799) 274.
Hebelia allemanica, C. C. Gmel. Fl. Bad. ii. (1806) 118, t. 1.
H. collina, C. C. Gmel. *l. c.*

Europe.

3. TOFIELDIA STENOPETALA, Smith, in Trans. Linn. Soc. xii. (1817) 243, t. 8. f. 1.

This species was founded on specimens collected by Kalm in North America, three of which are in the Linnean Herbarium. It has not been recorded since, but it seems probable that the species is distinct and that *T. calyculata* is exclusively European. Smith also described *T. alpina* as a species of the mountains of southern Europe, which is distinguished from *T. palustris* by being much larger in all its parts. At the same time he united *T. calyculata* with *T. palustris*. Ascherson and Graebner †, on the other hand, unite *T. alpina*, Smith, with *T. calyculata* (Linn.), Wahl., and recognize also *T. palustris*, Huds. The relationships of these four forms can only be determined by comparison of European and American specimens. Sir James Smith states that *T. stenopetala* is nearest *T. alpina*, from

* This apparently represents *T. alpina*, Sm., which is larger than *T. palustris*, Huds.
† Mitteleur. Fl. iii. (1905) 5.

which it differs in having an inflorescence which forms a dense obtuse cluster, 1½″ long; bracts lanceolate, often exceeding the pedicels; calyx very broad and shallow, usually 3-cleft, petals lanceolate and acute, anthers pointed, ovary ovato-lanceolate, styles twice as long as in *T. alpina*. It seems probable that further study will demonstrate the distinctness of this North American species, and perhaps also of the European *T. alpina*.

4. TOFIELDIA COCCINEA, Richardson, in Frankl. 1st Journ. (1823) 736; Hook. & Arn. Bot. Beechey's Voy. (1841) 130, t. 29 *bis*.

T. borealis, Cham. in Linnæa, vi. (1831) 584.

Arctic America.

4 *a*. TOFIELDIA COCCINEA, var. MAJOR, Hook., Fl. Bor. Am. ii. (1840) 179.

Mackenzie River (*Richardson*).

According to Hooker, this is easily distinguished (1) by its more flaccid leaves and leafy scape, (2) by its sessile flowers deeply tinged with red, (3) by its large bracts which form a deep involucre beneath the flower, (4) by the singularly deflexed dark purple fruit. It appears quite worthy of specific rank. The same form is recorded by Hooker from Siberia in Herb. Pallas.

Another variety, represented by two specimens collected by Richardson on the Mackenzie River, is mentioned by Hooker as having longer pedicels than the type of *T. coccinea*.

5. TOFIELDIA GLABRA, Nutt. Gen. Amer. i. (1818) 235; A. Gray, in Ann. Lyc. N.Y. iv. (1837) 136.

T. glaberrima, MacBride, in Ell. Sketch, i. (1821) 424.

North Carolina and South Carolina.

The total number of described species is about 32, over half of which are confined to Asia. The genus bears many resemblances to *Juncus*, and it may be supposed that the ancestors of *Tofieldia* gave rise to the Juncaceæ. This seems to the writer to be more probable than to read the series in the opposite direction. The genus *Tofieldia* contains more than 15 species in the north temperate zone and 3 species (*T. falcata*, Pers., *T. Moritziana*, H. Schultze, and *T. Schomburgkiana*, Oliver) in the Andes of South America. A number of species have been described from China and Japan in recent years.

T. borealis, Wahlenb., of Lapland, Tyrol, Labrador, etc., is apparently inseparable from *T. palustris*, Huds., unless it be in the presence or absence of pedicels to the flowers. *T. coccinea* differs from *T. borealis* in having more flaccid leaves of a duller colour and flowers sessile. *T. glabra* differs markedly from the other, more boreal, species of *Tofieldia* in America. It

occurs in North and South Carolina, and is tall rather than dwarfed, forming in this respect a transition to the genus *Triantha*. But it has neither the arrangement of the flowers in threes nor the scabrous pubescence on the stem characteristic of *Triantha*.

2. TRIANTHA (Nutt.), Baker.

1. TRIANTHA RACEMOSA (Walt.), Small, Fl. S.E. U.S. (1903) 249.

Melanthium racemosum, Walt. Fl. Car. (1788) 126.
Narthecium pubens, Michx. Fl. Bor. Am. i. (1803) 209.
N. scabrum, Rafin. in Desv. Journ. de Bot. iv. (1814) 273.
Tofieldia pubescens, Delar. in Redouté, Lil. vi. (1812) t. 324.
T. pubens, Hook. in Bot. Mag. (1841) t. 3859.
T. racemosa, Britton, Sterns, & Pogg, Prelim. Cat. N.Y. Plants (1888) 55; Ann. Rep. N.J. State Mus. 1910 (1911) p. 337, pl. 33. f. 1.

In swamps, southern New Jersey to Florida and Louisiana.

2. TRIANTHA GLUTINOSA (Michx.), Baker, in Journ. Linn. Soc., Bot. xvii. (1879) 490.

Narthecium glutinosum, Michx. Fl. Bor. Am. i. (1803) 210.
Tofieldia glutinosa, Pers. Syn. i. (1805) 399; Smith, in Trans. Linn. Soc. xii. (1818) 246, t. 8. f. 2; Hook. Fl. Bor. Am. ii. (1840) 179, t. 191.

In bogs, Newfoundland to Alaska, Minnesota, Maine, in the southern Alleghanies to N. Carolina and west to Ohio, Wyoming, and Oregon.

3. √TRIANTHA INTERMEDIA (Rydb.), comb. nov.

Tofieldia glutinosa, Hook. Fl. Bor. Am. ii. (1838) 179, partim; S. Wats. Bot. Calif. ii. (1880) 184.
T. intermedia, Rydb. in Bull. Torr. Bot. Club, xxvii. (1900) 528.

In bogs, Alaska to Saskatchewan, Montana, Wyoming, and Tulare Co., California.

4. √TRIANTHA OCCIDENTALIS (S. Wats.), comb. nov.

Tofieldia occidentalis, S. Wats. in Proc. Am. Acad. xiv. (1879) 283.

N. California (Mendocino Co.) to Washington and British Columbia, in mountains.

5. TRIANTHA JAPONICA (Miquel), Baker, in Journ. Linn. Soc., Bot. xvii. (1879) 490.

Tofieldia japonica, Miquel, Ann. Mus. Lugd.-Bat. iii. (1867) 201.

Japan, in swamps.

The genus *Triantha*, which contains the above five species, is properly separated from *Tofieldia* on account of (1) the scabrous pubescence, (2) the flowers in threes, and (3) the caudate seeds. The two western species, *T. occidentalis* and *T. intermedia*, should be included in this genus, since they have these three characters.

In this connection the case of *Tofieldia glabra* is of very much interest.

As already remarked, it agrees in habit with the species of *Triantha*, particularly *T. racemosa*, but differs sharply in two characters: (1) the absence of pubescence from the stem, (2) the flowers not arranged in threes. Its distribution is restricted, and it seems reasonable to conjecture that it may have originated from *T. racemosa* by two mutations. At any rate, it appears to differ from that species by what may very well be two unit characters, one of them a "loss" character. Certain specimens of *T. racemosa* from Carolina depart from the type in having the flowers for the most part not in threes but arranged as in *T. glabra*. Some of these may perhaps be hybrids between *Tofieldia glabra* and *Triantha racemosa*, or possibly mutations from the latter. Breeding experiments with those two forms could be profitably inaugurated, and a study of the forms occurring in North and South Carolina should also be made.

Triantha racemosa, which is more southern and much less widespread than *T. glutinosa*, differs from the latter mainly in (1) pubescence more scabrous, (2) perianth becoming rigid, (3) capsule firm, dark-coloured, long-beaked. Of the two western species, *T. intermedia* is not very sharply marked. It is distinguished from *T. glutinosa* by (1) having a short, more or less globose raceme, not elongated as in the eastern species; (2) having longer pedicels and oblong subequal perianth-segments (4 mm. long). *T. occidentalis* is somewhat more restricted in range than *T. intermedia*, from which it is distinguished by its narrower, less connate bractlets, longer pedicels, narrower sepals, larger capsules (8 mm. long), and longer ascending beaks. These are all quantitative differences, not sharply marked.

The third known species of *Triantha*, *T. japonica*, Baker, I have not seen. It is perhaps related to *T. intermedia*.

The three main differences between the closely related *Tofieldia* and *Triantha*—namely, (1) the arrangement of the flowers in clusters of three instead of singly on the stem, (2) the appearance of a characteristic rough pubescence, (3) the caudate seeds—are such as might have resulted from three mutations. But, if so, where are the forms exhibiting only a single one of these changes, and why have only the forms containing all three been preserved? There is perhaps no utility in any of these characters, but it would appear that only forms having all three of these features, or lacking them all, have survived. Yet to suppose the passage from *Tofieldia* to *Triantha* in a single step requires a much larger change than we know from experience. These are but a few of the questions raised by a consideration of the two genera.

3. PLEEA, Michaux.

PLEEA TENUIFOLIA, Michx. Fl. Bor. Am. i. (1803) 248, t. 25; Delar. in Redouté, Lil. v. (1809) t. 248; Sims, in Bot. Mag. (1818) t. 1956.

In pine-land swamps, S. Carolina to Florida.

This very interesting monotypic genus differs from *Triantha* and *Tofieldia* chiefly in the following points:—

Triantha (Nutt.), Baker.	*Pleea*, Michx.
Bracts short.	Bracts spathe-like.
Flowers subtended by 3 connate bractlets.	Bractlets wanting.
Stamens 6.	Stamens 9–12.
Anthers rounded, erect.	Anthers elongated, versatile.

Pleea is evidently isolated, and a considerable amount of extinction must have occurred between it and its nearest relatives, *Tofieldia*, *Triantha*, and *Narthecium*. Regarding the comparison with *Triantha*, it is more likely that the bractlets subtending the flowers were suddenly lost by a negative mutation than that they were gradually reduced until they finally disappeared. The increase in size and change in shape of the bracts may have occurred independently, as also the addition of one or two whorls of stamens. The change from the short, subglobose, erect, terminal anthers of *Tofieldia* to the long, narrow, versatile anthers of *Pleea* probably involved several different germinal changes. Some species of *Luzula* have elongated erect anthers, so the versatile character probably appeared through an independent change in a related ancestral line.

4. NARTHECIUM, Moehring.

1. Narthecium ossifragum, Huds. Fl. Angl. 145; Sm. in Engl. Bot. viii. (1799) t. 535.

   N. anthericoides, Hoppe, in Mert. & Koch, Deutschl. Fl. ii. (1826), 559.
   N. palustre, Bub. Fl. Pyren. iv. (1901) 169 *.
   Anthericum ossifragum, Linn. Sp. Pl. (1753) 446; Fl. Dan. (1761) t. 42.
   Abama ossifraga, DC. in Lam. Fl. Fr. ed. 2, iii. 171; DC. in Redouté, Lil. iv. (1808) t. 218.

   Europe.

2. Narthecium americanum, Ker, in Bot. Mag. (1812) t. 1505.

   N. ossifragum, var. *americanum*, A. Gray, Man. ed. 5 (1867) 536.
   Abama americana, Morong, in Mem. Torr. Bot. Club, v. (1894) 109; Ann. Rep. N.J. State Mus. 1910 (1911) 338, pl. 33. ff. 2–3; Bartonia, iv. (1911) 1, t. 1.

   Pine barren swamps, southern New Jersey, and Delaware.

This species is extremely local in its distribution. It was discovered by Pursh at Quaker Bridge, New Jersey, about 1805. He sent plants to Kew, from which the figure was made for the 'Botanical Magazine.' Witmer Stone † gives an account of its present distribution. After the lapse of a

* A full list of figures is given here.

† *Abama americana* (Ker), Morong, in 'Bartonia,' iv. (1911) 1–5.

century since its original discovery, *N. americanum* is now (with one exception) known only from fifteen localities, included in an area about 20 by 30 miles. It was always supposed to be restricted to the heart of the New Jersey Pine Barrens, but specimens in Herb. Phila. Acad. Sci. were collected by Mr. A. Common near Lewes, Delaware, on Aug. 1, 1895. The plant is more restricted now than formerly, because it is killed by cranberry culture.

3. NARTHECIUM CALIFORNICUM, Baker, in Journ. Linn. Soc., Bot. xv. (1876) 351.

N. ossifragum, var. *occidentale*, A. Gray, in Boland. Pl. Calif. (1870) 31.
Abama californica, Heller, Cat. N. Amer. Pl. (1898).
A. occidentalis, Heller, in Muhlenbergia, i. (1904) 47.

California, Mendocino Co., and northwards into Oregon, and in the Sierras to the Yosemite National Park. The type came from Del Norte Co., California.

4. NARTHECIUM ASIATICUM, Maxim. in Bull. Acad. Pétersb. xi. (1867) 438. Japan.

This genus is particularly interesting on account of its discontinuous distribution, no one of the four species coming in contact with any of the others. And yet, though widely separated geographically, the species are closely similar. *N. asiaticum* appears to represent the oldest species, and is found in Japan. *N. ossifragum* occurs throughout Europe and in Asia Minor. *N. americanum* is confined to a narrow area about New Jersey, where it is rare; and *N. californicum* appears chiefly in Northern California. These two species are both fairly close to *N. ossifragum*, of which they have been regarded as varieties, but they appear to be worthy of specific recognition.

The differences between the species are as follows:—In *N. ossifragum* the leaves are about 7·5–15 cm. long and 3–6 mm. wide, 4–6-nerved; the stamens one-third shorter than the perianth-segments, which are narrowly linear, 6–7 mm. long, considerably exceeding the stamens; capsule 10 mm. long, and persistent style one-half longer than the perianth; raceme of few flowers, 2·2–5 cm. long; plant usually 15–25 cm. high. In *N. americanum* the leaves are narrower (2–3 mm. wide), the stamens scarcely shorter than the perianth, the capsule and style twice as long as the perianth.

A sheet of *N. ossifragum* in Herb. Univ. Calif. contains four specimens from Alingsås, Sweden ,*L. Linquist*, July 1878, all of which are larger and stouter. The leaves are 4–10 mm. wide, 5–7-nerved, plants 25–30 cm. high, perianth-segments 6–8 mm. long.

The following differences are pointed out in the 'Botanical Magazine':—

N. americanum differs from *N. ossifragum* in (1) much shorter pubescence, (2) whole plant smaller, (3) leaf and stem somewhat yellower, (4) one of the bracts not above the middle of the pedicel but near its base, (5) corolla much paler yellow, (6) anthers yellow instead of vermilion. According to Pursh they differ only in (4) the position of the bracts. Comparison of herbarium specimens confirms all the above differences except (1) and (6). *N. americanum* is decidedly less stout and more yellowish, while the perianth is paler yellow. The difference in the position of the bracts is apparently a constant feature, but there appears to be no difference in pubescence or in the colour of the anthers *.

N. californicum is intermediate between *N. americanum* and *N. ossifragum* in width of leaves, its raceme is rather lax below, and the stamens about half the length of the perianth. The filaments are also white-woolly to the top, unlike the other three species, in which the summit of the filaments is naked. In *N. californicum* the base of the filaments is frequently naked. *N. asiaticum* I have not seen, but it apparently differs from *N. ossifragum* in having wider leaves (2–3 lines) with conspicuous veins and a longer raceme.

Examination of a number of specimens shows the following differences between *N. americanum* and *N. californicum* :—

N. americanum.	*N. californicum.*
Leaves usually about 2 mm. wide, 7–9-nerved.	Leaves about 3–4 mm. wide, 5–7- or 8-nerved.
Raceme dense, 2·5–8 cm. long.	Raceme lax, 7–12 cm. long.
Perianth-segments narrowly linear, 5–6 mm. long, slightly exceeding the stamens.	Perianth-segments oblong-linear, 8–10 mm. long, considerably exceeding the stamens. Plants from the type-locality have orange-coloured perianth-segments in fruit.
Capsules 10–11 mm. long.	Capsules 13–15 mm. long.
Plant 30–40 cm. high.	Plant 33–60 cm. high.

Hence *N. californicum* is somewhat larger, though not markedly so, in all its parts. The number of leaves in the nerves is often the same, but they are farther apart in *N. californicum.*

The following specimen in the Herbarium of the California Academy of Science is much reduced, and is apparently like the eastern species:—Desolation Valley, Lake Tahoe Region, Cal., *Louise Hutchinson*, Aug. 1909. The plant is 2 dm. high, the leaves about 1 mm. wide, 3–4-nerved, 4–5 cm. long, the raceme 4·5 cm. long, perianth-segments 5–6 mm. long, about 1 mm. wide. This raises the question as to whether the differences between *N. americanum* and *N. californicum* may not be environmentally induced.

* It is possible, however, that in *N. ossifragum* there may be a dimorphism in the colour of the anthers similar to the condition found by C. H. Danforth in *Tiarella cordifolia* ('Rhodora,' xiii. (1911) 192–3).

It would be very instructive to transplant *N. americanum* to California and *vice versâ*, and observe the results in successive generations.

A segregate from *N. ossifragum* has been described by Celakovsky * from Corsica as *N. Reverchoni*. It differs chiefly in having squamous bracts at the base of the stem, larger flowers and longer erect pedicels, and in the hairs of the filaments, which increase in length from below upwards.

A remarkable peculiarity of the genus *Narthecium* is the dense pile of white woolly hairs on the filaments. This is probably a feature which is of no service to the plant, but which persists throughout the genus because of inheritance, and it very likely originated through a mutation; which may have been one of several mutations which gave rise to the generic characters of *Narthecium*. The specific differences as above outlined are chiefly of a quantitative nature, although the species are so widely separated in space. The variations which gave rise to these species have evidently been small, and many of them might very well be considered of quantitative nature. It appears that these are exactly the type of variations which Darwin contemplated in his theory of natural selection. Whether these small differences are actually of survival value may perhaps be doubted. The question could be settled without difficulty in this case by transplanting each species into the range of the others and determining whether it succeeds or fails in competition with another species in its native habitat. While these morphological differences are small, it may well be that they are correlated with invisible physiological changes which are important in the economy of the species.

The genus *Narthecium* was formerly placed in the family Juncaceæ. The differences between it and its nearest relatives, *Triantha* and *Xerophyllum*, are, unlike the specific differences within the genus, sharp and distinctive, though *Tofieldia* and *Narthecium* are remarkably alike in habit. The latter is compared with *Triantha* † in the following table:—

Triantha (Nutt.), Baker.	*Narthecium*, Juss.
No rootstock.	A creeping rootstock.
Flowers mostly in threes in a centrifugal panicle, white or greenish.	Flowers in a terminal raceme, greenish yellow.
Perianth-segments for the most part not nerved.	Perianth-segments obscurely 3–5-nerved.
Filaments slender.	Filaments subulate, *woolly*.
Anthers rounded, erect.	Anthers linear-oblong, erect, introrse.

* Oest. Bot. Zeitschr. xxxvii. (1887) 154.

† *Lophiola aurea*, Ker, representing another monotypic North-American genus, is found in pine barrens from New Jersey to Florida. It is usually placed in the Hæmodoraceæ, and is rather remote from *Narthecium* in many features, but suggests a resemblance in having tufts of wool at the base of the perianth-segments on which the stamens are inserted. The inflorescence and upper part of the stem are, however, also clothed with soft matted wool, as in *Lachnanthes tinctoria*, Ell.

The two monotypic genera, *Nietneria* and *Petrosaria*, are placed by Engler* next to *Narthecium*, though the affinities of the latter are doubtful and the former has been placed in the Hæmodoraceæ. *Nietneria corymbosa*, Klotzch & Schomb., occurs in the mountains of British Guiana. *Petrosaria stellaris*, Beccari, is a root-parasite without leaves, found in Borneo. They are only remotely related to the present group of genera.

The genus *Metanarthecium* of Maximowicz, containing two species in Japan, also resembles *Narthecium* in certain respects.

5. XEROPHYLLUM, Michaux.

1. Xerophyllum asphodeloides, Nutt.
   X. asphodeloides, Nutt. Gen. i. (1818) 235.
   X. setifolium, Michx. Fl. Bor. Am. i. (1803) 211; Ann. Rep. N.J. State Mus. 1910, p. 340, pl. 35 (1911).
   Helonias asphodeloides, Linn. Sp. Pl. ed. 2 (1762) 485; Curt. Bot. Mag. (1804) t. 748; Lodd. Bot. Cab. iv. (1819) t. 394.

   Dry pine barrens, southern New Jersey to eastern Tennessee and Florida.

2. Xerophyllum tenax, Nutt.
   X. tenax, Nutt. Gen. i. (1818) 235.
   X. setifolium, Lindl. Bot. Reg. (1833) t. 1613, not Michx.
   Helonias tenax, Pursh, Fl. Am. Sept. i. (1814) 243, t. 9.

   On high lands near the Rocky Mountains, British Columbia to Montana, and California (Monterey Co.). Abundant, covering hundreds of acres in some localities.

3. Xerophyllum Douglasii, S. Wats. in Proc. Am. Acad. xiv. (1879) 284.
   ? *X. setifolium*, var., A. Gray, in Proc. Amer. Acad. viii. (1872) 405.

   Oregon, Columbia River (*Hall*), Montana, Idaho.

The genus *Xerophyllum* is remarkably distinct from its nearest relatives, *Narthecium* on the one hand and *Helonias* on the other. The three species are closely in agreement with each other, the differences being entirely quantitative. Like so many Pacific coast species, *X. tenax* is much larger than its eastern congener, *X. asphodeloides*. Lindley, who studied plants grown from seed collected by Douglas in the north-west, was "unable to detect the slightest mark by which they may be separated," though his figure shows a wider-leaved plant than *X. asphodeloides*. *X. tenax* is generally much larger and stouter, with broader leaves (4–6 mm.), the leaves of *X. asphodeloides* being very narrow (1–2 mm.). The flowers of *X. tenax* are also somewhat larger, and the stamens exceed the perianth-segments. The seeds also are said to differ slightly in shape. It is possible that *X. tenax* is a tetraploid species, though this seems improbable.

* Nat. Pflanzenfam. T. ii. Abt. v., Liliaceæ, p. 20 (1887).

According to Jepson *, *X. tenax* at Mt. Tamalpais, Calif., appears to bloom only once in seven years; and at Howell Mountain, Napa Co., it is said to fruit only once in five years. Plants in Sonoma Co. show "an irregular perianth; the (apparently) upper perianth-segment is keeled, the two adjoining ones auricled or strongly oblique on the upper side at base; leaves somewhat revolute-concave as if channelled."

The following specimens of *X. tenax* have narrow leaves (2 mm. or more) as in *X. asphodeloides*, but flowers somewhat larger (6–8 mm. long) as in the true *X. tenax* :—

S. Fork Mountain, Humboldt Co., Cal., *Chesnut and Drew*, July 21, 1888, Univ. Cal. Herb. 13722. On plains near Mendocino City, Cal., 4784, *H. N. Bolander*, May 8, 1866, U. C. Herb. 4083 and 4084. Mt. Tamalpais, Marin Co., Cal., *Alice Eastwood*, June 16, 1901, U. C. Herb. 167934. Mt. Eddy, Siskiyou Co., Cal., 3872, *Dr. E. B. Copeland*, Sept. 6, 1903, U. C. Herb. 142151. Mt. Tamalpais, Cal., *Alice Eastwood*, May 1, 1898, U. C. Herb. 142057.

It appears that narrow-leaved forms are most frequent in some localities, and there are plants with leaves of intermediate width as well, as in specimens from Yamhill Co., Oregon.

X. Douglasii is an obscure and little-known species. It may be questioned whether it is distinguishable from the eastern species, with which it evidently agrees in most particulars. It is said to have shorter pedicels than *X. tenax* (12–30 mm., instead of 3–5 cm), smaller flowers, very short styles (1″, instead of 2″ long), a cordate-ovate, 6-valved capsule, and shorter and broader seeds. None of the western specimens I have seen corresponds with all these requirements. Intermediates between *X. Douglasii* and *X. tenax* probably occur. The latter species is exceedingly abundant in Idaho, where it often covers hundreds of acres †.

S. Watson ‡ speaks of *X. Douglasii* as follows :—"Found in the mountains from the Columbia to Montana, is a similar species [to *X. tenax*] with a narrower raceme of smaller flowers; stamens included; styles a line long; capsule cordate-ovate, 2 lines long, the very abruptly acute cells usually separating and then dehiscing loculicidally; seeds shorter and broader."

The distribution of the genus is interesting, the single species of the south-eastern United States being widely sundered from *X. tenax* of the Rocky Mountain region. It is perhaps worth pointing out that the main difference between *X. asphodeloides* and *X. tenax* is similar to that between *Stenanthium gramineum* and *S. robustum*, namely in general size and leaf-width. In the latter case, however, both species occupy much the same area, though

* Jepson, W. L., Fl. W. Mid. Calif. p. 124 (1901).

† According to Piper, Fl. State Washington, Contrib. U.S. Nat. Herb. xi. (1906) 197.

‡ Bot. Calif. ii. (1880) 186.

S. robustum is somewhat more northern and more restricted. Hence if it originated from *S. gramineum* through a mutation, its origin must have been relatively recent; while the origin of *Xerophyllum tenax*, if it was derived from *X. asphodeloides*, is more likely to have occurred before their present wide separation in space. It is not necessary to assume that intermediates occurred and have since become extinct in the intervening region. Indeed, I know of no facts which would justify this assumption.

The main differences between *Xerophyllum* and *Narthecium* may be set forth as follows:—

Narthecium.	*Xerophyllum.*
Leaves linear, those of the stem short and distant.	Leaves narrowly linear, rough-margined, the upper ones shorter than the lower, plants larger.
Flowers small, greenish-yellow.	Flowers very numerous, medium-size, white.
Pedicels with a short bract at base, and usually bearing a small bractlet.	Pedicels with a long bract at base, but without a bractlet.
Perianth-segments obscurely 3–5-nerved.	Perianth-segments usually 5–7-nerved.
Filaments woolly, anthers introrse.	Filaments glabrous, anthers extrorsely dehiscent.
Style very short or none, stigma slightly 3-lobed.	Styles 3, filiform, reflexed or recurved.
Capsule oblong.	Capsule ovoid, 3-grooved.
Seeds many, linear, tailed at each end.	Seeds 5, oblong, not appendaged or only minutely so.

Though *Narthecium* and *Xerophyllum* resemble each other in foliage and habit, yet the differences in inflorescence and flower-structure are numerous and necessitate the assumption of a considerable amount of extinction between these forms. It is useless to hazard a guess as to the number of mutations involved in the passage from one genus to the other, though there must have been several. Of course, one genus did not give rise to the other, but *Xerophyllum* probably came through a series of definite variations from an ancestor of *Narthecium* in which the variation producing woolly filaments had not yet occurred.

6. HELONIAS, Linn.

HELONIAS BULLATA, Linn.

> *Helonias bullata*, Linn. Sp. Pl. (1753) 342, and Amœn. Acad. iii. (1756) 12, t. 1. f 1 Mill. Ic. (1758) 181, t. 272; Bot. Mag. (1804) t. 747; Lam. Illustr. (1823) t. 268; Lodd. Bot. Cab. (1824) t. 961; DC. in Redouté, Lil. i. (1805) t. 13; Ann. Rep. N.J. State Mus. (1910), p. 340, pl. 36 (1911); Bartonia, iii. 1 (1910) t. 1.
> *Helonias latifolia*, Michx. Fl. Bor. Am. i. (1803) 212.
> *Veratrum americanum*, Mill. Gard. Dict. ed. 8 (1768) n. 4.

In bogs, southern New York and northern New Jersey to Virginia, and in the mountains of North Carolina. Rare and local. In New York it is known

from only one locality, near Rossville, Staten Island *. Its northern limit is probably Morris Co., N.J., and it is most abundant in southern New Jersey. The plant was originally discovered by Kalm near Philadelphia, probably on April 26, 1749, at Pennsneck, N.J. It was formerly supposed to have occurred in eastern Pennsylvania, but this record was probably a mistake. The range of the species was only recently extended to North Carolina †, where it was found to be common in sphagnum swamps of the Pink Bed Valley, Transylvania Co., in thickets of *Kalmia*, *Alnus*, and *Viburnum*. It was found in full bloom April 29, 1909, and was distributed as No. 4117.

Miller speaks of the plant as follows: *Veratrum racemo simplicissimo, corollis patentibus, staminibus longioribus.* "This is titled by Mr. John Bartram, who discovered the plant growing naturally in North America, *Veratrum sempervirens.*" Miller received the plant from Peter Collinson, later a specimen and drawing from Mr. John Bartram, Jr., and he afterwards obtained more plants from Dr. Bensel, of German Town, in Philadelphia, "who found it growing plentifully in shady moist places."

This monotypic genus of eastern North America is evidently disappearing, and on account of its isolation must be regarded as the sole survivor of a group of forms. Its nearest relative is the Asiatic genus *Heloniopsis*, A. Gray, containing three species in Japan and one in Formosa. This is another instance of the remarkable similarity between the floras of eastern North America and Japan. According to Gray, *Heloniopsis pauciflora* combines the extrorse anthers of Colchicaceæ with the loculicidal capsule, entire style, and capitate stigma of the Liliaceæ, and a mass of little seeds tailed at one or both ends as in *Juncus* and *Narthecium*, in addition to its resemblances to *Helonias*. It is like a *Helonias* with a single slender style, few flowers, depressed-capitate stigma, and seed appendaged only at the hilum.

The genera *Xerophyllum* and *Helonias* may be compared as follows:—

Xerophyllum.	*Helonias.*
Leaves narrowly linear, rough-margined.	Basal leaves oblanceolate, persistent.
Flowers very numerous, medium size, white, in a large, dense, terminal raceme.	Flowers rather large, purple, in a terminal raceme, on a hollow, bracted scape.
Perianth-segments oblong or ovate, 5–7-nerved.	Perianth-segments spatulate.
Stamens shorter than the perianth-segments.	Stamens longer than the perianth-segments.
Filaments subulate, anthers oblong.	Filaments filiform, anthers ovate, blue.
Capsule ovoid, 3-grooved.	Capsule obovoid, deeply 3-lobed.
Seeds 5, not appendaged or only minutely so.	Seeds numerous, white-appendaged at each end.

The contrasts in texture and habit of these plants are much greater than appears in a catalogue of their main taxonomic differences.

* The following facts are taken from Stewardson Brown, in 'Bartonia,' iii. (1910) 1–6.

† House, H. D., in 'Muhlenbergia,' vi. (1910) 73.

7. CHAMÆLIRIUM, Willd.

This is another monotypic genus of eastern North America, but is somewhat less isolated than the preceding.

CHAMÆLIRIUM LUTEUM, A. Gray.

C. luteum, A. Gray, Man. (1848) 503.
C. carolinianum, Willd. in Ges. Nat. Fr. Berl. Mag. ii. (1808) 19.
C. obovale, Small, in Torreya, i. (1901) 108.
Veratrum luteum, Linn. Sp. Pl. (1753) 1044; Amœn. Acad. iii. (1756) 12, t. 1. f. 2.
V. flavum, Herb. ex Schult. f. Syst. Veg. vii. (1830) 1565.
Melanthium dioicum, Walt. Fl. Car. (1788) 126.
M. luteum, Willd. in Ges. Nat. Fr. Berl. Mag. ii. (1808) 22.
M. densum, Lam. Encyc. iv. (1823) 26, t. 269. f. 2.
Helonias pumilia, Jacq. Icon. Rar. (1786-1793) 2, t. 453.
H. lutea, Ker-Gawl. in Bot. Mag. (1807) t. 1062.
H. dioica, Pursh, Fl. Am. Sept. i. (1814) 243.
Ophiostachys virginica, Delile, in Redouté, Lil. viii. (1816) t. 464.
Diclinotrys, Raf. Neogen. iii. (1825).

This species is much more widespread than the preceding ones, occurring from Ontario, Michigan, and Massachusetts, south to Florida and west to Nebraska and Arkansas.

C. obovale, described by Small from New York, New Jersey, and the mountains of West Virginia to North Carolina and Alabama, is said to differ from *C. luteum* in having capsules obovoid or oblong-obovoid (not oblong or ovoid-oblong), 12–14 mm. (not 7–10 mm.) long, pedicels stout, club-shaped, about as long as the capsule (not 1–5 mm. long). The stem is also said to be zigzag, the leaves various, and the flowers larger. I have seen specimens showing some of these capsule characters, but they appear to be too vague and evanescent to serve for specific distinction.

Redouté's figure differs somewhat in foliage from that in the Botanical Magazine. The latter has elliptical-lanceolate leaves, pointed, with 3 or 4 main parallel nerves; the former broader, ovate-elliptical to obovate leaves, obtuse, petioled and pinnately veined.

The following comparison shows the differences between *Helonias* and *Chamælirium*:—

Helonias, Linn.	*Chamælirium*, Willd.
Flowers perfect, rather large, purple.	Flowers diœcious, small, white.
Scape stout, hollow, sparsely bracted, flowers in a bractless raceme.	Scape slender, bearing small lanceolate leaves, flowers in a long bractless spike-like raceme.
Anthers blue.	Anthers white.
Ovary ovoid, 3-grooved.	Ovary oblong.
Capsule obovoid, deeply 3-lobed, the lobes divergent.	Capsule oblong or obovoid, slightly 3-lobed.

Seeds numerous, linear, white-appendaged at each end.	Seeds 6–12 in each cavity, linear-oblong, broadly winged at both ends, narrowly winged at the sides.
Leaves lanceolate, the lowest spatulate, tapering into a petiole.	Leaves oblong-spatulate or oblanceolate, evergreen.

It is difficult to estimate the value of the differences between these two genera, or the number of steps which would be necessary to bridge the gap between them. But I believe we are more likely to be right in thinking of the differences as having come about through definite variations than in picturing the gradual accumulation of infinitesimal differences.

8. AMIANTHIUM, A. Gray.

1. AMIANTHIUM MUSCÆTOXICUM, A. Gray.

A. muscætoxicum, A. Gray, in Ann. Lyc. N.Y. iv. (1837) 122.
Melanthium muscætoxicum, Walt. Fl. Car. (1788) 125.
M. lætum, Soland. in Ait. Hort. Kew. i. (1789) 488.
M. myoctonum, J. F. Gmel. Syst. Veg. i. (1796) 587.
Helonias læta, Ker, in Bot. Mag. (1805) t. 803; Lodd. Bot. Cab. (1824) t. 998.
H. erythrosperma, Michx. Fl. Bor. Am. i. (1803) 212.
Amiantanthus muscætoxicum, Kunth, Enum. Plant. iv. (1843) 180.
Zigadenus muscætoxicus, Regel, Gartenfl. xxxii. (1883) 164, t. 1121. f. 1.
Chrosperma muscætoxicum, Kuntze, Rev. Gen. Pl. (1891) 708.

Long Island and eastern Pennsylvania to Florida, Tennessee, Missouri, and Arkansas.

2. AMIANTHIUM ANGUSTIFOLIUM, A. Gray.

A. angustifolium, A. Gray, in Ann. Lyc. N.Y. iv. (1837) 124.
Anthericum subtrigynum, Jacq. Ic. Rar. ii. (1793) t. 419.
Helonias angustifolia, Michx. Fl. Bor. Am. i. (1803) 212.
H. læta, β. minor, Ker-Gawl. in Bot. Mag. (1813) t. 1540.
Zygadenus angustifolius, S. Wats. in Proc. Am. Acad. xiv. (1879) 280.
Tracyanthus angustifolius, Small, Fl. SE. Un. St. (1903) 251.
Melanthium phalangioides? Lam. Encyc. iv. (1823) t. 269. f. 4.

North Carolina to Florida, in moist pine woods.

3. AMIANTHIUM TEXANUM, comb. nov.

Tracyanthus angustifolius, var. *texanus*, Bush, Rep. Mo. Bot. Gard. xvii. (1906) 119.
T. texanus, Small, Fl. S.E. Un. St. 2nd ed. (1913) p. 1329.

In sandy swamps, eastern Texas.

The genus *Amianthium* of Gray (*Chrosperma*, Rafin.) contains three species: *A. muscætoxicum*, extending from Long Island to Penn., Florida, and Arkansas; *A. angustifolium* of narrower distribution, from N. Carolina to Florida; and *A. texanum* in Texas. The latter two species have been placed in a separate genus, *Tracyanthus*, by Small, but it would be difficult to find

a reason for creating a new genus in this case. *A. angustifolium* is smaller, and it differs from *A. muscætoxicum* in its narrower leaves and smaller flowers, in addition to certain minor differences, as in the shape of the sepals and relative length of the stamens. But intermediates in certain localities occupied by both species make it very difficult to draw any definite line between them. Indeed, the two forms are by no means always easily separated. There is a possibility of tetraploidy here. *Amianthium*, *Xerophyllum*, and *Stenanthium* are all examples of essentially bitypic genera, in which the two species differ chiefly in having broad or narrow leaves. This type of dimorphism is a common one in the plant kingdom, and probably has some special explanation which is at present obscure. *Schœnocaulon dubium* and *S. Drummondii* form a similar pair (see p. 150). *A. texanum* differs from *A. angustifolium* in its larger size, broader leaves, large compound panicles, and decidedly yellowish flowers, the perianth-segments being oval, 4–5 mm. long. It resembles *Stenanthium*, but the panicle is much smaller and less branched and the perianth-segments not narrow and acuminate. The differences between *Chamælirium* and *Amianthium* will appear in the following comparative table :—

Chamælirium.	*Amianthium.*
Bitter, tuberous rootstock.	Ovoid-oblong coated bulb.
Basal leaves short, spatulate, tapering into a petiole; stem-leaves lanceolate.	Basal leaves numerous, long, linear, and blunt; stem-leaves few and short.
Flowers small, diœcious, in a long, narrow, bractless, spike-like raceme.	Flowers perfect, in a dense terminal raceme.
Perianth-segments linear-spatulate, 1-nerved, withering-persistent.	Perianth-segments obtuse, persistent.
Anthers subglobose.	Anthers reniform, stamens inserted on the base of the sepals.
Ovary oblong or obovate, somewhat grooved.	Ovary ovoid, with 3 divergent lobes.
Styles short, stigmatic along the inner side.	Styles subulate.
Capsules slightly 3-lobed, ellipsoid.	Capsules 3-celled, dehiscent above the middle.
Seeds 6-12 in each cavity, linear-oblong, broadly winged at both ends, narrowly winged at the sides.	Seeds 1–2 in each cavity, ovoid, reddish brown.

The diœcism of *Chamælirium* and the bulb of *Amianthium* separate these genera much more widely than their other morphological features, which show many resemblances. Diœcism has been attained independently a number of times, but we do not know whether it is usually accomplished by one step from hermaphroditism, or whether the passage is more gradual through monœcism and polygamodiœcism *. The bulbous condition has also

* The converse change, from diœcism to hermaphroditism, seems to have occurred much earlier in the evolution of the flower.

no doubt been independently derived many times, as we see in *Amianthium*, *Anticlea*, and *Allium* within this group. It is more difficult to visualize the passage from a rootstock to a bulb than in the above case of diœcism. It is very difficult to believe that the passage is ever abrupt, and in certain plants, such as *Amianthium*, the condition appears to be somewhat intermediate, the bulbous condition not having been fully arrived at.

Amianthium is perhaps more closely related to *Schœnocaulon*, whose main distinguishing features are as follows:—

Schœnocaulon.	*Amianthium.*
Fibrous-coated bulbs.	Bulb-like rootstocks.
Leaves basal, narrowly linear.	Leaves linear, blunt-pointed, those of the stem much fewer and shorter.
Flowers in slender spikes, or in spike-like racemes with short pedicels.	Flowers larger, in cylindrical racemes with long pedicels.
Perianth green, persistent, sepals and petals narrow.	Perianth white, sepals and petals broad.
Seeds slender, nearly terete.	Seeds thick, reddish brown.

9. SCHŒNOCAULON, A. Gray.

The genus contains about twelve species, of which all but two are confined to Mexico and will not be considered here. These two are as follows:—

1. Schœnocaulon dubium (Michx.) Small.

S. dubium, Small, Fl. SE. Un. St. (1903) 250.
S. gracile, A. Gray, in Ann. Lyc. N.Y. iv. (1837) 127.
Helonias dubia, Michx. Fl. Bor. Am. i. (1803) 213.

In dry pine lands, Georgia and Florida.

2. Schœnocaulon Drummondii, A. Gray; Hook. & Arn. Bot. Beechey Voy. (1841) 388.

S. texanum, Scheele, in Linnæa, xxv. (1852) 262.

On prairies, Texas and Northern Mexico.

These two species, apparently discontinuous in their distribution, form an interesting pair:—

S. dubium: compact portion of spike 5 mm. thick; sepals oblong; capsules sessile.
S. Drummondii: compact portion of raceme 10 mm. thick; sepals linear; capsules pedicelled.

S. Drummondii is stouter in every part, having larger flowers and wider leaves. *S. dubium* has apparently been derived from it by reduction. It is not a dwarf in the ordinary sense, but more like a miniature. The chromosome relations of these species would be worth looking into.

10. STENANTHIUM, Kunth.

This genus as now recognized contains only two species.

1. STENANTHIUM GRAMINEUM (Ker), Morong.

S. gramineum, Morong, in Mem. Torr. Club, v. (1894) 110.
S. angustifolium, Kunth, Enum. iv. (1843) 190.
Helonias graminea, Ker, in Bot. Mag. (1813) t. 1599.
Veratrum angustifolium, Pursh, Fl. Am. Sept. i. 242, ii. 747 (1814).
Xerophyllum gramineum, Nutt. Gen. i. (1818) 235.

Virginia to Kentucky, Missouri, Alabama, and Florida.

2. STENANTHIUM ROBUSTUM, S. Wats., in Proc. Am. Acad. xiv. (1879) 278.

Pennsylvania and Ohio to South Carolina, Tennessee, and Missouri.

These two species have been united by some writers, but *S. robustum* is no doubt worthy of independent recognition. It is larger and stouter, as the name indicates, and may be a tetraploid mutant or cell-giant from *S. gramineum*. In *S. robustum* the capsule is erect, in *S. gramineum* reflexed. The former has leaves 4–6 mm. wide; the latter, leaves 6–20 mm. wide. The capsules of *S. robustum* are also larger (10 mm. long, instead of 8 mm.) and the perianth is said to be usually green, while in *S. gramineum* it is usually white.

The two species occupy nearly the same territory, *S. robustum* extending a little further north and not so far south. Intermediate specimens are not improbably hybrids. A careful anatomical comparison of these species should be made.

The genus *Stenanthium* is closely related to *Amianthium*, which it resembles in foliage and with which it agrees in having bulb-like rootstocks. There are, however, conspicuous differences in inflorescence and flower-structure, as shown in the following comparison:—

Amianthium, Gray.	*Stenanthium*, Kunth.
Leaves linear, blunt-pointed, stem-leaves few and short.	Leaves linear, narrower, blunt-pointed, basal leaves less numerous.
Flowers perfect, white, in a dense terminal cylindrical raceme.	Flowers polygamous, white or greenish, in an ample terminal panicle.
Perianth-segments broad, obtuse.	Perianth-segments narrowly lanceolate, acuminate, spreading.
Stamens as long as or longer than the perianth-segments.	Stamens shorter than the perianth-segments.
Capsule 3-celled, dehiscent above the middle, the divergent lobes tipped by the subulate styles.	Capsule ovoid-oblong, 3-lobed, dehiscent to base, the lobes with short, slightly divergent beaks.

The paniculate inflorescence and narrow acuminate petals of *Stenanthium* are its most striking features. The change in the petals might represent a single variation, but it is difficult to say whether one or two germinal changes could transform the racemose inflorescence of *Amianthium* into the loose

panicle of *Stenanthium*. It may suffice to point out that the traditional conception of gradual transition is based upon suppositions which require proof as much as do those of sharp steps. If crossing experiments between these two genera could be instituted, it might throw light on the nature of all these differences.

11. STENANTHELLA, Rydb.

The genus *Stenanthella* was segregated from *Stenanthium* by Rydberg, to contain the two species *S. sachalinensis* (F. Schmidt), Rydb., and *S. occidentalis*. To these should be added *S. frigidum* from Mexico, which stands much nearer to *Stenanthella* than to *Stenanthium*. The North-American species are then as follows:—

1. STENANTHELLA OCCIDENTALIS (A. Gray), Rydb.

S. occidentalis, Rydb. in Bull. Torr. Bot. Club, xxvii. (1900) 531.
Stenanthium occidentale, A. Gray, in Proc. Amer. Acad. viii. (1872) 405.

Alberta and British Columbia to Oregon and Montana, and south to Trinity Co., California.

2. STENANTHELLA FRIGIDA (Schlecht. et Cham.), comb. nov.

Veratrum frigidum, Schlecht. et Chamisso, in Linnæa, vi. (1831) 46.
Zigadenus frigidus, D. Don, in Edinb. N. Phil. Journ. (1832) 233.
Stenanthium frigidum, Kunth, Enum. Plant. iv. (1843) 189.

Mexico.

In *S. frigida* the ovary is partly inferior, but this alone is not sufficient reason for separating it from *S. occidentalis*, which it otherwise clearly resembles. It differs from the latter chiefly in its somewhat larger size, larger flowers, dark purple perianth, and shorter and less pointed capsules.

The genus *Stenanthella*, which is markedly distinct from *Stenanthium*, differs mainly in the following characters:—

Stenanthium.	*Stenanthella.*
Inflorescence a large panicle of many sessile flowers.	Inflorescence a raceme of few flowers on long pedicels.
Flowers polygamous, small, white or greenish, open, not campanulate.	Flowers perfect, much larger, greenish, brownish, or purplish, campanulate.
Tips of perianth-segments not reflexed.	Tips of perianth-segments reflexed and finally involute.

12. ZIGADENUS, Michaux.

1. ZIGADENUS GLABERRIMUS, Michx. Fl. Bor. Am. i. (1803) 214, t. 22; Del. in Redouté, Lil. viii. t. 461 (1816); Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 280, pl. 12. f. 1.

Helonias glaberrima, Link, Enum. Hort. Berol. i. (1821) 348.

In swamps, Virginia to Florida, and west to Mississippi, usually near the coast.

Specimens: Bolling, Butler Co., Alabama, *John D. Smith*, 1884. Ocean Springs, Miss., *J. Skehan*, 1895. Long Beach, Miss., *J. F. Joor*, 1891.

2. ZIGADENUS BRACTEATUS, Roem. & Schult. Syst. vii. (1830) 1559.

Helonias bracteata, Sims, Bot. Mag. (1815) t. 1703; Lodd. Bot. Cab. (1828) t. 1330.

This has usually been referred to *Z. glaberrimus*, but it appears to be a different species, though I have seen no specimens. It is stated in Lodd. Bot. Cab. to be native of Carolina and Georgia, whence it was introduced into cultivation in 1802. The species differs from *Z. glaberrimus* in its very much larger and broader bracts and shorter pedicels. In *Z. glaberrimus* the bracts scarcely equal the pedicels in length, while in *Z. bracteatus* they exceed the flowers. The inflorescence is also perhaps more compact and the petals apparently broader. This species should be looked for in association with *Z. glaberrimus*, with which it has apparently been confused. The figure in the Bot. Mag. is evidently from a very young specimen in which the inflorescence has not yet elongated, but, nevertheless, the size and shape of the bracts seem to separate it from *Z. glaberrimus*.

13. ANTICLEA, Kunth.

1. ANTICLEA SIBIRICA (Linn.), Kunth.

Melanthium sibiricum, Linn. Sp. Pl. (1753) 339.

Zigadenus sibiricus, Kunth, Enum. Pl. iv. (1843) 192; Endl. Gen. 135; A. Gray, in Ann. Lyc. N.Y. iv. (1837) 112.

Anticlea sibirica, Kunth, Enum. Pl. iv. (1843) 191; Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 280, pl. 13. f. 4.

Siberia.

2. ANTICLEA JAPONICA (Makino), comb. nov.

Zigadenus japonicus, Makino, in Bot. Mag. Tokyo, xvii. (1903) 162.

Japan.

Said to resemble *A. elegans*, but has smaller flowers, narrower not glaucous leaves, stem shorter, and pedicels shorter. It apparently differs from *A. sibirica*.

3. ANTICLEA ELEGANS (Pursh), Rydb.

Zigadenus elegans, Pursh, Fl. Am. Sept. i. (1814) 241.

Helonias glaberrima, Ker, in Bot. Mag. (1814) t. 1680.

? *Asphodelo affinis floridana, ramoso caule, floribus Ornithogali obsoletis*, Pluk. Amalth. (1705) p. 40, t. 372. f. 3.

Anticlea elegans, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 273, pl. 13. f. 3.

Zigadenus dilatatus, Greene, Pl. Baker. i. (1901) 51. Colorado.

Zigadenus alpinus, Blankin. in Mont. Agr. Coll. Sci. Studies, Bot. i. (1905) 44.

Anticlea alpina, Heller, in Muhlenbergia, vi. (1910) 12. Montana.

Saskatchewan to Alaska, south to Colorado, Nevada, and Minnesota.

4. Anticlea chlorantha (Richards), Rydb.

A. glauca, Kunth, Enum. Pl. iv. (1843) 192.
A. chlorantha, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 273.
Zigadenus chloranthus, Richards. in Frankl. 1st Journ. (1821) 736.
Z. glaucus, Nutt. in Journ. Phila. Acad. vii. (1834) 56; Lindl. in Bot. Reg. xxiv. (1838) t. 67.
Z. canadensis, Hort. ex Baker, in Journ. Linn. Soc., Bot. xvii. (1879) 482.
Z. chloranthus, β. *major*, Hook. & Arn. Bot. Beechey Voy. (1841) 402.
Z. glaberrimus, Hook. & Arn. Bot. Beechey Voy. (1841) 160.
Melanthium glaucum, Nutt. Gen. i. (1818) 232.

New Brunswick to Minnesota and south to Vermont.

5. Anticlea coloradensis, Rydb.

A. coloradensis, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 273.
Zigadenus coloradensis, Rydb. in Bull. Torr. Bot. Club, xxvii. (1900) 534.
Z. elegans, var. *coloradensis*, M. E. Jones, in Bull. Univ. Mont., Biol. Ser. xv. (1910) 22.

Colorado.

Specimens: Red Creek, Colo., *N. L. T. Nelson*, July 18, 1908 (2 sheets). Near Empire, Colo., *H. N. Patterson*, 298, July 28, Sept. 6, 1892. Jarbridge, Head of Jack and Swamp Creeks, 2018, *Nelson and Macbride*, July 11, 1912. These specimens are by no means uniform, but they represent some at least of the supposed peculiarities of *A. coloradensis*.

According to Rydberg, this species differs from *A. elegans* in its "smaller flowers, greener foliage, long and narrow bracts equalling or exceeding the pedicels, and a brownish or purplish tint of the inflorescence, bracts, and flowers." These differences are, however, by no means sharp in all cases, and intermediates occur in size of flowers and colour and length of bracts. The leaves vary in width from 3–15 mm. The perianth-segments are said to be 7–8 mm. long in *Z. elegans*, 5–6 mm. in *Z. coloradensis*; 7–13-nerved in the former, 3–7-nerved in the latter.

The toxic properties of several species of *Zigadenus* are discussed in a recent Bulletin *. It was found that *Anticlea elegans*, *Toxicoscordion venenosum* and *T. paniculatum* were constantly poisonous to sheep, while *A. coloradensis*, though it contained small quantities of alkaloid, was not very toxic. This perhaps indicates the specific distinctness of the last species, for the properties of each species were found to be generally constant. But *T. venenosum* from one locality was less toxic than when collected elsewhere.

6. Anticlea vaginata, Rydb. in Bull. Torr. Bot. Club, xxxix. (1912) 108.

Utah.

Differs from other species in its habit of growing in big clumps, and in its numerous loose sheaths at the base of the stem. In the perianth it resembles

* Marsh, C., Dwight, Clawson, A. B., and Marsh, H., 1915. "*Zygadenus*, or Death Camas." Bull. No. 125, U.S. Dept. Agr. pp. 46, pls. 6, including 3 figs. of "*Z. venenosus*."

A. coloradensis, and in their veins *A. porrifolia*. The perianth-segments are smaller than in the former and broader than in the latter. *A. vaginata* resembles *A. porrifolia* also in its branched inflorescence, but has shorter pedicels and broader leaves.

7. ANTICLEA LONGA (Greene), Heller.

A. longa, Heller, in Muhlenbergia, vi. (1910) 12.
Zigadenus longus, Greene, Pittonia, iv. (1901) 240.

Oregon.

8. ANTICLEA PORRIFOLIA (Greene), Rydb.

A. porrifolia, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 273.
Zigadenus porrifolius, Greene, in Bull. Torr. Bot. Club, viii. (1881) 123.

New Mexico.

Pale and soft, garlic-like, somewhat glaucous leaves; bulb oblong with white outer coats; raceme simple or few-branched below; bracts ovate-lanceolate, green and glaucous; flowers small, nodding; perianth adnate, persistent, segments greenish, broad, none unguiculate; gland elongated, truncate, or obcordate.

9. ANTICLEA MOHINORENSIS (Greenm.), comb. nov.

Zigadenus mohinorensis, Greenm. in Proc. Amer. Acad. xxxix. (1903) 71.

Chihuahua, Mexico.

Nearest to *A. elegans*, from which it differs in its somewhat larger flowers, more conspicuous and longer bracts of the inflorescence, and in the nature of the glands, which are obcordate or Y-shaped, erose-margined.

10. ANTICLEA VOLCANICA (Benth.), Baker.

A. volcanica, Baker, in Journ. Linn. Soc., Bot. xvii. (1879) 482.
Zigadenus volcanicus, Benth. Pl. Hartweg. (1842) 96.

Guatemala.

11. ANTICLEA VIRESCENS (H. B. K.), Rydb.

A. virescens, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 273.
Helonias virescens, Kunth, Nov. Gen. Voy. Humb. et Bonpl. i. (1815) 267.
Veratrum virescens, Mart. et Gal. Enum. Pl. Mex. 10; Kunth, Enum. Pl. iv. (1843) 698.
Melanthium virescens, Willd. Herb. No. 7076 (ex Kunth, *l. c.*).
Anticlea mexicana, Kunth, Enum. Pl. iv. (1843) 193.
Zigadenus mexicanus, Hemsl. Biol. Centr.-Am., Bot. iii. (1885) 382.
Zigadenus volcanicus, S. Wats. in Proc. Am. Acad. xviii. (1883) 165.

Mexico.

12. ANTICLEA GRACILENTA (Greene), comb. nov.

Zigadenus gracilentus, Greene, Pittonia, iv. (1901) 241.

Mexico.

Said to be nearly related to *A. elegans*, but distinguished by the oblanceolate leaves and the diœcious flowers.

14. TOXICOSCORDION, Rydberg.

1. TOXICOSCORDION VENENOSUM (S Wats.), Rydb.

T. venenosum, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 272.
Zigadenus venenosus, S. Wats. in Proc. Am. Acad. xiv. (1879) 279.
Z. Nuttallii, S. Wats. partim, in Bot. King's Exped. v. (1871) 343.

British Columbia to California. Not east of Wyoming. The type may be considered to come from Monterey Co., Calif. Watson's description included plants from the Coast Range and also from the Sierra Nevada. These belong to distinct species, and the Monterey Co. locality is selected merely because mentioned first. That the Sierran species is distinct is proven by specimens of the flowers shown me by Dr. H. M. Hall. The flowers of the latter are much smaller, and the stamens exserted beyond the petals.

2. TOXICOSCORDION INTERMEDIUM, Rydb.

T. intermedium, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 272, pl. 13. f. 2.
T. gramineum, Rydb. *l. c.* xxx. (1903) 272.
Zigadenus intermedius, Rydb. *l. c.* xxvii. (1900) 535.
Z. gramineus, Rydb. *l. c.*
Z. venenosus, var. *ambiguus*, M. E. Jones, in Contrib. West. Bot. xii. (1908) 77.

Montana, Idaho, Wyoming, and Utah.

Rydberg now considers (*l. c.* xxxix. 109, 1912) that *T. gramineum* cannot be separated from *T. intermedium*, being a dry hill state of the same with smaller flowers and narrower leaves. It is doubtful if this species can be separated from *T. venenosum*.

3. TOXICOSCORDION ACUTUM, Rydb.

T. acutum, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 272.
Zigadenus acutus, Rydb. *l. c.* xxvii. (1900) 536.

South Dakota.

This is said by Rydberg to be easily distinguished from *T. venenosum* by "the acute short-clawed petals and sepals, which are both cuneate at the base." The species is apparently not well marked.

4. TOXICOSCORDION SALINUM (A. Nelson), comb. nov.

Zigadenus salinus, A. Nelson, in Coult. Bot. Gazette, liv. (1912) 406.

Idaho.

This species is near to *T. venenosum* and *T. intermedium*, but has globose bulbs and small glands. It lives in alkali-bog lands.

5. Toxicoscordion arenicola, Heller, in Muhlenbergia, ii. (1906) 182.

Inyo Co., California, Washoe Co., Nevada.

This is a segregate from *T. venenosum.* The bulbs are broadly ovoid, clothed with dark brown outer coats. The leaves about half the length of stem. Inflorescence at first short and dense, becoming 1–2 dm. long; pedicels very slender, spreading and ascending; bracts membranous, acuminate; perianth white, segments faintly 3-toothed at the apex and very short-clawed, with a small, yellow, orbicular, fimbriate gland just above the claw.

6. Toxicoscordion Nuttallii (A. Gray), Rydb.

T. Nuttallii, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 272.
Amianthium Nuttallii, var. *a,* A. Gray, in Ann. Lyc. N.Y. iv. (1837) 123.
Amiantanthus Nuttallii, Kunth, Enum. Pl. iv. (1843) 181.
Anticlea Nuttallii, Torr. Pacif. R. R. Rep. iv. (1856) 144.
Zigadenus Nuttallii, A. Gray, Man. ed. 2 (1857) 476; Gartenfl. xxxii. (1883) 163 t. 1121. f. 2.
Helonias angustifolia, Nutt. in Trans. Am. Phil. Soc. v. (1837) 154.

Colorado, Kansas, and Arkansas.

Bulb with blackish skin, white within, sepals variable, gland small, roundish, without distinct margin.

7. Toxicoscordion Fremontii (Torr.), Rydb.

T. Fremontii, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 273.
Zigadenus speciosus, Dougl. ex Hook. Fl. Bor. Am. ii. (1840) 177.
Z. glaberrimus, Hook. & Arn. Bot. Beechey Voy. (1843) 160.
Z. Douglasii, Torr. Pacif. R. R. Rep. vii. (1856) 20.
Z. Fremontii, Torr. ex S. Wats., Bot. King's Exped. v. (1871) 343.
Z. glaucus, Nutt. ex Baker, in Journ. Linn. Soc., Bot. xvii. (1879) 480.
Anticlea Fremontii, Torr. Pacif. R. R. Rep. iv. (1856) 144.

California.

Sepals not clawed, 5–7-nerved, gland irregular-margined above; stamens half as long as the perianth.

✓Toxicoscordion Fremontii (Torr.), Rydb., var. minor (Hook. & Arn.), comb. nov.

Zigadenus chloranthus, a, minor, Hook. & Arn. Bot. Beechey Voy. (1841) 402.
Z. commutatus, Schult. Syst. Veg. vii. (1830) 1561.
Z. speciosus, var. *minor,* Greene, Man. Bay Region, (1894) 315.
Z. Fremontii, var. *minor,* Hook. & Arn. fide Jepson, Fl. W. Mid. Calif. (1901) 122.

Smaller in every part. This is an early dwarf form, 4 or 5 inches high, with few flowers, in open wet ground near the coast (Jepson, Fl. 122).

8. Toxicoscordion exaltatum (Eastw.), Heller.

T. exaltatum, Heller, in Muhlenbergia, vi. (1910) 83.
Zigadenus exaltatus, Eastw. in Coult. Bot. Gazette, xli. (1906) 283.

California.

This is said by the author to be the largest species of *Zigadenus* and to be related to *T. paniculatum* in habit and size of bulb, but the flower parts are of different shape.

9. TOXICOSCORDION BREVIBRACTEATUS (M. E. Jones), comb. nov.

Zigadenus Fremontii, var. *brevibracteatus*, M. E. Jones, Contrib. West. Bot. xii. (1908) 78.
Z. brevibracteatus, Hall, in Univ. of Cal. Publ., Botany, vi. (1915) 165.

Victor, Calif., and along the southern borders of the Mohave Desert.

Differs in having very narrow leaves, small flowers, ample compound racemes, stout horizontal pedicels 25–40 mm. long, and ovate-lanceolate bracts. This is a desert species.

10. TOXICOSCORDION PANICULATUM (Nutt.), Rydb.

T. paniculatum, Rydb. in Bull. Torr. Bot. Club, xxx. (1903) 272.
Helonias paniculata, Nutt. in Journ. Philad. Acad. vii. (1834) 57.
Amianthium Nuttallii, var. *β*, Gray, in Ann. Lyc. N.Y. iv. (1837) 123.
Zigadenus paniculatus, S. Wats. in Bot. King's Exped. v. (1871) 343.
Z. Nuttallii, var. *paniculatus*, Baker, in Journ. Linn. Soc., Bot. xvii. (1879) 481.

Montana and Washington to New Mexico and California.

Distinguished, according to Rydberg, by its "stout habit, generally branched inflorescence, and rhombic-ovate, acute, and almost clawless petals and sepals."

11. TOXICOSCORDION FALCATUM, Rydb.

T. falcatum, Rydb. Bull. Torr. Bot. Club, xxx. (1903) 272.
Zigadenus falcatus, Rydb. *l. c.* xxvii. (1900) 536.

Colorado.

The following specimens in Herb. Missouri Bot. Gard. are referred to this species: Canon City, Colo., 24, *T. S. Brandegee*, May, 1871. Fort Collins, Colo., *C. S. Crandall*, May 17, 1894 (cotype). Denver, Colo., *E. C. Smith*, May 21, 1891. Near Fort Collins, *C. F. Baker*, May 24, 1896.

Said to differ from *T. paniculatum* in the distinctly clawed petals, which are subcordate at base. "These characters, together with the more distinct glands and the slightly adnate filaments, distinguish it from *T. Nuttallii*."

12. TOXICOSCORDION MICRANTHUM (Eastw.), Heller.

T. micranthum, Heller, in Muhlenbergia, vi. (1910) 83.
Zigadenus micranthus, Eastw. in Bull. Torr. Bot. Club, xxx. (1903) 483.

Mendocino Co., California.

It is very doubtful if this differs from the true *T. venenosum*.

13. TOXICOSCORDION TEXENSE, Rydb. ex Small, Fl. S.E. Un. St. (1903) 252, 1328.

Texas.

Raceme many-flowered; perianth yellow, segments clawed, subcordate, about 5 mm. long; glands half-orbicular, the upper edge free.

15. OCEANORUS, Small.

OCEANORUS LEIMANTHOIDES (A. Gray), Small.

Amianthium leimanthoides, A. Gray, in Ann. Lyc. N.Y. iv. (1837) 125.
Amiantanthus leimanthoides, Kunth, Enum. Pl. iv. (1843) 183.
Zigadenus leimanthoides, A. Gray, Man. ed. 2 (1857) p. 476.
Helonias graminea, Ell. Herb. (ex Kunth, *l. c.*).
Oceanorus leimanthoides, Small, Fl. S.E. Un. St. (1903) 252, 1328.

Long Island to Georgia and Tennessee.

The old genus *Zigadenus* has been broken up into four closely related genera. These are *Anticlea*, Kunth, Enum. iv. (1843) 191; *Toxicoscordion*, Rydberg, in Bull. Torr. Bot. Club, xxx. (1903) 272, and *Oceanorus* Small, Fl. S.E. Un. St. (1903) 252, leaving *Zigadenus* itself with two species, only one of which is known in the wild condition. *Z. glaberrimus* comes close to *Melanthium*, so close that very good reasons might be adduced for including it in that genus. The differences between these genera are as follows:—

Plant with a rootstock; perianth-segments each with two glands. *Zigadenus*.
Plant with a bulb-like rootstock; perianth-segments each with a single thick gland. *Oceanorus*.
Plant with a bulb; perianth-segments each with a single gland.
Plant poisonous, ovary wholly superior; gland obovate or semi-orbicular. *Toxicoscordion*.
Ovary partly inferior; gland obcordate or notched. *Anticlea*.

The habit, with a rootstock or bulb; and the number and shape of the glands at the base of the perianth-segments, are thus the main distinguishing features. It is reasonable to suppose that the gland differences at any rate may have originated by single steps. *Anticlea* and *Toxicoscordion*, the former having about 10 species in North America and two in northern Asia, and the latter with about 12 species in western N. America, might be regarded as the oldest genera. But, so far as I am aware, the bulbous condition, which has arisen independently in many families, has always been derived from an ordinary stem or a rootstock, and not *vice versâ*. Hence we must regard the ancestor of *Zigadenus glaberrimus* as representing the original stem, from which in one direction *Z. glaberrimus* was derived, perhaps through a mutation in which the basal glands became divided into two, while in *Z.* (*Oceanorus*) *leimanthoides* the bulb-like development began, to be completed in the ancestors of *Toxicoscordion* and *Anticlea*. In the latter, meantime, the glands became obcordate or more or less bifurcated, and the ovary partly inferior.

It is necessary to assume an extinct ancestor having a rootstock and a single undivided gland. Aside from this, there is no evidence of

any extinction having taken place between these genera. There is, for example, no gap between the species of *Toxicoscordion* and those of *Anticlea*. In the absence of such a gap, the separation of these two genera is by no means a sharp one, and indeed is only justifiable on grounds of convenience. Since *Z. glaberrimus* is confined to the south-eastern States, while *Toxicoscordion* and *Anticlea* cover a much wider area, it may perhaps be assumed, considering also the other relationships of *Zigadenus*, that its origin took place relatively recently. On the other hand, it is possible that it may be a survivor of a group similar to the present *Anticlea*.

The distinctions between species in *Anticlea* and *Toxicoscordion* are founded chiefly upon such features as the shape of the perianth-glands, the size and shape of sepals and petals, whether clawed or clawless, the width of leaves, and the nature of the raceme. These differences are for the most part not sharply marked presence and absence characters, but tend to be quantitative and continuous. This makes the discrimination of species difficult. The two genera are, in fact, in rather a chaotic condition, owing partly to the nature of the specific differences, partly to their variability, and partly to the description of a number of new species on a rather slender basis and from insufficient material to determine the range and manner of variation of the various forms.

In the preceding pages I have merely assembled the species, some of which will very likely be reduced to synonymy, but the genus can only be adequately treated after some botanist has made a careful study in the field.

We have already concluded that the present *Zigadenus* represents an ancestral condition from which *Oceanorus*, *Anticlea*, and *Toxicoscordion* were derived. On the other hand, *Zigadenus* has clearly led to *Melanthium*, and *Melanthium* to *Veratrum* through the loss of the glands on the perianth-segments. Hence we may conclude that *Zigadenus* is the oldest genus in this section of the Melanthaceæ. Presumably it and *Stenanthium* are descended from a common ancestor, *Zigadenus* having developed the pairs of glands on the perianth-segments and also the claws on these segments. How these two features developed, we have at present no means of knowing, but there has probably been considerable extinction between the present genera *Zigadenus* and *Stenanthium*.

16. MELANTHIUM, Clayt., ex Linn.

1. Melanthium virginicum, Linn. Sp. Pl. (1753) 339; Lamk. Encyc. iv. (1823) 24, t. 269. f. 1.

M. lætum, Kinn, ex Kunth, Enum. Pl. iv. (1843) 195.

M. biglandulosum, Bertol. in Mem. Acc. Sc. Bologn. ii. (1850) 316.

Asphodelus elatior Floridanus gramineis foliis, floribus parvis et herbaceo-pallescentibus, Pluk. Amalth. (1705) 40, t. 434. f. 8.

Leimanthium virginicum, Willd. Sp. Pl. ii. (1799) p. 266; A. Gray, in Ann. Lyc. N.Y. iv. (1837) 115, partim.

Helonias virginica, Sims, Bot. Mag. (1806) t. 985.

Veratrum virginicum, Ait. Hort. Kew. ed. 2, v. (1813) p. 426.

Zigadenus virginicus, Kunth, Enum. Pl. iv. (1843) 195 partim.

In meadows and swamps, Rhode Island to Minnesota, and south to Florida and Texas.

2. MELANTHIUM HYBRIDUM, Walt. Fl. Carol. (1788) 125; Pursh, Fl. Am. Sept. i. (1814) 241; Ell. Sketch, i. (1821) 418.

M. racemosum, Michx. Fl. Bor. Am. ii. (1803) 251.

M. latifolium, Desrouss. in Lam. Encyc. iv. (1797) 25.

Leimanthium hybridum, Schult. Syst. Veg. vii. (1830) 1550; A. Gray, in Ann. Lyc. N.Y. iv. (1837) 115.

Zigadenus hybridus, Kunth, Enum. Pl. iv. (1843) 196.

In dry woods and on hills, Connecticut to Pennsylvania, and South Carolina.

3. MELANTHIUM MONOICUM, Walt. Fl. Carol. (1788) 125; Pursh, Fl. Am. Sept. i. (1814) 241; Ell. Sketch, i. (1821) 418.

M. polygamum, Desrouss. in Lam. Encyc. iv. (1797) 25.

M. dispersum, Small, in Bull. Torr. Bot. Club, xxv. (1898) 606.

Leimanthium monoicum, Schult. Syst. Veg. vii. (1830) 1550; A. Gray, in Ann. Lyc. N.Y. iv. (1837) 116 partim.

In woods. This species appears to be quite restricted in distribution. Small described his *M. dispersum* from Walton Co., in the north of Florida, and the following specimen is in Herb. Missouri Bot. Gard.: Sphagnous bog about 2 miles east of Folkston, Charlton Co., Georgia, 1506, *Roland M. Harper*, Aug. 12, 1902. Pursh gives as the distribution, "on the mountains of Virginia and Carolina."

This genus of three species is confined for the most part to south-eastern North America, though *M. virginicum* extends farther north and west. *M. monoicum* occurs on the borders of Florida and Georgia, and probably also in Virginia and Carolina. The main specific differences are as follows:—

M. virginicum.	*M. hybridum.*
Leaves linear, acuminate, 4″–12″ wide.	Leaves oblanceolate, acute, 6″–2′ wide.
Flowers 6″–10″ broad, greenish yellow.	Flowers 6″–8″ broad, greenish white.
Perianth-segments oblong, obtuse, flat, entire, blade at least twice as long as the claw *.	Perianth-segments orbicular or ovate, undulate or crisped, blade longer than the narrow claw.

M. monoicum, Walt., differs from *M. virginicum* in having (1) longer and narrower leaves, (2) a very broad instead of a narrow panicle, (3) fewer flowers on stouter pedicels, (4) perianth-segments thicker and with shorter claws. The stamens are attached near the top of the claw.

* The perianth-segments are also usually more pubescent on the outside.

Melanthium is closely related to *Zigadenus*, which it resembles in having the perianth-segments clawed, with two glands at the base of the blade, but the glands in *Melanthium* tend to be confluent. The two genera also resemble each other in foliage and in inflorescence, but *Zigadenus* is glabrous while *Melanthium* is characteristically scabrous-pubescent. As regards the stamens, they are free from the perianth-segments and about equalling them in length in *Zigadenus*, while in *Melanthium* they are shorter than the segments to which they are adnate. The seeds of the former are oblong or linear, while those of the latter are flat and broadly winged. The capsules also show characteristic differences. Thus in *Melanthium* they are truncate at the top, while in *Zigadenus* they are more gradually narrowed and pulled out, as it were, at the points where the stigmas protrude. Another difference is found in the flowers, which are monœcious in *Melanthium*, hermaphrodite in *Zigadenus*.

The differences between the three species of *Melanthium* are typical specific differences, and there is no direct evidence as to how they came about. The genus is closely related to *Zigadenus* on the one hand, and through *V. parviflorum* to *Veratrum* on the other hand. The scabrous pubescence of *Melanthium* may be supposed to have originated suddenly in a *Zigadenus*-like ancestor. The differences in relative stamen-length and in the adnation of the stamens to the petals are no greater than in the species of, e. g., *Trillium*. Hence it is unnecessary to suppose any greater amount of extinction between these three genera than occurs between species of the same genus.

The resemblances and differences between *Melanthium* and *Veratrum* are pointed out in the following table. The two genera agree in certain features, such as the pubescence and the shape of the seeds, in which they are contrasted with *Zigadenus*. On the other hand, *Melanthium* and *Zigadenus* are closely similar in the glands on the perianth, which in *Veratrum* have been almost completely lost :—

Melanthium.	*Veratrum.*
	Rootstocks poisonous.
Stem and inflorescence scabrous-pubescent.	Stem and inflorescence pubescent.
Leaves narrow, sheathing.	Leaves broad, clasping, strongly veined.
Flowers greenish, white or cream-colored; monœcious or polygamous; on slender pedicels; in large terminal panicles.	Flowers greenish, yellowish, or purple, rather large; monœcious or polygamous; on short stout pedicels; in large terminal panicles.
Perianth-segments clawed, with 2 more or less confluent glands at base, mostly free from the ovary.	Perianth-segments not clawed, glandless or nearly so, sometimes adnate to the base of the ovary.
Stamens shorter than the perianth-segments and adnate to them.	Stamens shorter than the perianth-segments and free from them.
Seeds very flat, broadly winged.	Seeds very flat, broadly winged.

We may now consider the synonymy of the three species of *Melanthium*, together with that of *Veratrum parviflorum*, Michx., which has often been included in the same genus. It will be seen that *M. monoicum*, Walter, replaces *M. dispersum*, Small, and *M. hybridum*, Walt., takes the place of *M. latifolium*, Desrouss. The reasons for these changes are as follows: Walter, in the 'Flora Caroliniana,' recognizes the three known species of *Melanthium* under a special section of his genus *Melanthium* which is thus described: "Petalis unguiculatis imprimis albis demum obscuro-rubris seminibus semiovatis." The first species is *M. virginicum*, Linn., the second he describes as *M. hybridum*, and the third as *M. monoicum*. Let us consider *M. monoicum* first. It is described as follows: "Petalis planis, maculis 2 luteis; floribus inferioribus masculis majoribus, paniculis lateralibus; superioribus fœmineis racemo terminali." Pursh describes the species as follows: "M. panicula inferne mascula, superne feminea racemosa, petalis oblongis planis breviunguiculatis bimaculatis, stylis germine duplo brevioribus. Walt. Fl. Car. 125." He adds that the flowers are smaller than in *M. virginicum*, and not so apt to change colour. Elliott merely repeats the description of Pursh.

There can be no doubt concerning the identity of this species with the *M. dispersum* of Small. Particularly the oblong flat petals with two glands and a short claw, and the flowers smaller than in *M. virginicum*, serves to identify the species; also the broad panicle and the fact that the upper flowers are mostly pistillate. This identification clears up a long-standing difficulty with Walter's *M. monoicum*. Assurance is made doubly sure by the detailed description of *Leimanthium monoicum*, Schult., in which measurements and numerous other details are given.

When *M. monoicum*, Walt., has been identified, the remaining synonymy falls easily into place. The identity of *M. hybridum*, Walt., is not quite so conclusive as that of *M. monoicum*, but that it is the same as *M. latifolium*, Desrouss., there can be very little doubt. Britton * has referred it there with a question mark, which I think must be removed now that Walter's *M. monoicum* is recognized.

The description of *M. hybridum* by Walter is in these words: "petalis plicato-undulatis immaculatis, floribus masculis et fœminis mixtis." The word "immaculatis" has been the source of trouble, for the other two features, (1) undulate petals and (2) staminate and pistillate flowers intermingled, are peculiarities of this species, while glands are usually present on the perianth-segments as in other species of *Melanthium*. The description of Pursh, however, leaves no possible doubt as to the plant intended, for he says under *M. hybridum*: "M. panicula superne racemosa feminea, petalis subrotundis plicato-undulatis vix maculatis, extus hirsutis." He gives as

* Britton & Brown, Ill. Fl. i. (1896) 407.

synonyms *M. latifolium*, Lam. Encycl. iv. p. 25, and *M. racemosum*, Michx. Fl. Amer. i. p. 251. He further states that the flowers are "small, pale white, and do not change." That Michaux's *M. racemosum* is the same plant is shown by the character of the petals in his description: "panicula recemoso-oblonga, confertiuscula; laciniis calycinis orbiculatis."

Elliott, under the name *M. hybridum*, Walt., also clearly describes this species, his diagnosis being as follows: "M. panicula pubescente, racemosa; petalis orbiculatis, plicatis, longe unguiculatis; glandulis coalitis." He further says, "glands forming an emarginate circle, at the summit of the claw, with a furrow along the centre," which exactly describes the usual condition in this species.

In the absence of glands, Nuttall concluded that *M. hybridum*, Walt., must be the plant now known as *Veratrum parviflorum*, Michx., which Nuttall clearly describes under the name *M. hybridum*. But Asa Gray, in his description of *M. hybridum*, Walt., under the name *Leimanthium hybridum*, mentions that the glands are sometimes obsolete. It is evident, then, that Walter founded his description on plants of this character. Gray's full description is as follows: "Foliis lineari-lanceolatis, elongatis; perianthii foliolis anguste unguiculatis, lamina rhomboideo-suborbiculata, margine undulata; glandulis conniventibus (quandoque obsoletis); unguibus convoluto-canaliculatis, infra medium staminiferus." He evidently gave the species careful study, for he describes* three forms of *Leimanthium hybridum* (*M. hybridum*, Walt.) as follows:—

"α gracilis; panicula sparsiflora, ramis plerisque simplicibus.

"β robustior; foliis inferioribus plantagineis; ramis imis paniculæ compositis.

"γ elata; ramis paniculæ plerisque compositis, multifloris."

A study should be made of these forms, which differ in the branching of the panicles and in the foliage.

The Schultes' description of *L. hybridum* adds further details. There remains, then, no reasonable ground for doubt that Pursh, Elliott, and Asa Gray were right in their designation of *M. hybridum*, Walt., which must therefore be known under that name.

Gray was less fortunate in his characterization of *Leimanthium monoicum*. His description is that of *Veratrum parviflorum*, while his synonymy refers in part to *M. monoicum*. Kunth also made the mistake of describing *Veratrum parviflorum* under the name *Zigadenus monœcus*. Gray also confused *Melanthium virginicum*, Linn., with *M. hybridum*, Walt., under the name *Leimanthium virginicum*, while Kunth following him confused the same forms under the name *Zigadenus virginicus*.

* A. Gray, in Ann. Lyc. New York iv. (1837) 115.

17. VERATRUM, Tourn.; Linn.

1. VERATRUM PARVIFLORUM has been considered with the genus *Melanthium* because its synonymy has been entangled with that genus, standing as it does in some respects intermediate between these two genera. We may now consider the remaining species of *Veratrum*.

2. VERATRUM VIRIDE, Ait. Hort. Kew. iii. (1789) 422; Bigel. Amer. Med. Bot. ii. (1818) 121, t. 33.

V. album, Michx. Fl. Bor. Am. ii. (1803) 249, non Linn.
Helonias viridis, Ker, in Bot. Mag. (1808) t. 1096.

In swamps and wet woods, New Brunswick and Quebec to Ontario, south to Georgia and Tennessee, west to Minnesota.

3. VERATRUM WOODII, Robbins, in Wood, Classbook, ed. 2, 557 (1855).
Dry woods and hills, S. Indiana to Missouri, Illinois, and Iowa.
Specimens: Hancock Co., Ill., *S. B. Mead*, 1842. (resembles *V. intermedium*). Desmoines River opp. Portland, Iowa Terr., *Chas. A. Geyer*, 1841.

4. VERATRUM INTERMEDIUM, Chapm. Flora S. Un. St. (1860) 489.
Middle Georgia to middle Florida.
Specimens: Gadsden Co., Fla., *Chapman*, 1837. Foot of Stone Mountain, De Kalb Co., Ga., *Eggert*, 1897 (resembles *V. Woodii*).

5. VERATRUM CALIFORNICUM, Durand, in Journ. Phila. Acad. iii. (1855) 103; Piper, Fl. Washington, Contrib. U.S. Nat. Herb. xi. (1906) 196, pl. 20.

V. album, S. Wats. Bot. King's Exped. 344.
V. speciosum, Rydb. in Bull. Torr. Bot. Club, xxvii. (1900) 531.

Washington State to California, Colorado, and Montana.

6. VERATRUM FIMBRIATUM, A. Gray, in Proc. Amer. Acad. vii. (1868) 391.
Calif. (Mendocino Co.) along the coast.

7. VERATRUM CAUDATUM, Heller, in Bull. Torr. Bot. Club, xxvi. (1899) 588.
Western Washington.

8. VERATRUM JONESII, Heller, in Muhlenbergia, i. (1905) 124. Idaho.

9. VERATRUM TENUIPETALUM, Heller, *l. c.* i. (1904) 39. Colorado.

10. VERATRUM ESCHSCHOLTZII (Schult. f.), A. Gray.

V. Eschscholtzii, A. Gray, in Ann. Lyc. New York, iv. (1837) 119.
V. Lobelianum, β. *Eschscholzianum*, Schult. f. Syst. vii. (1830) 1555.
V. parviflorum, Bongard. in Mém. Acad. St. Pétersb. ser. 6, ii. (1831) 166.

Alaska and British Columbia.
Specimen: Rodman Bay, Alaska, 56, *Mrs. K. Stephens*, Aug. 15, 1907, Univ. Cal. Herb. 127687.

The poisonous genus *Veratrum* contains some 17 species in the north temperate zone. In northern Asia are found *V. album*, Linn., and *V. nigrum*, Linn., and several other species. Of the North American species *V. parviflorum*, *V. viride*, *V. intermedium*, and *V. Woodii* may be ranked as eastern species. *V. parviflorum*, Michx., is frequently included in *Melanthium*, but in the absence of glands on the perianth-segments and in view of its close relationship to *V. intermedium* and *V. Woodii* there is no doubt that it is properly excluded from *Melanthium*.

In distribution, *V. viride* is spread most widely, extending west to Minnesota in wet habitats. *V. parviflorum* occurs in drier localities on mountains from Virginia to South Carolina, *V. intermedium* in Georgia and Florida, while *V. Woodii* occurs farther west, in Indiana, Illinois, Missouri, and Iowa. It must be said, however, that *V. intermedium* and *V. Woodii* are particularly difficult to separate, and this difficulty is enhanced by finding from Georgia certain specimens (Foot of Stone Mountain, De Kalb Co., Georgia, *H. Eggert*, July 23, 1897) verging on *V. Woodii* and from Illinois a specimen (Hancock Co., Ill., *S. B. Mead*, July, 1842) practically inseparable from *V. intermedium*. The differences between the species in their typical condition are as follows:—

V. Woodii: Perianth-segments broad, purple; pedicels typically very short, 2″ or less.

V. intermedium: Perianth-segments narrower, dark brown within; pedicels 3″–4″ long.

On the other hand, *V. intermedium* comes nearest *V. parviflorum*, from which it is clearly separated, however, as follows:—

V. intermedium: Stamens nearly as long as perianth-segment, ovary pubescent.

V. parviflorum: Stamens less than half as long as the perianth-segment, ovary smooth.

In the two features of *V. intermedium* above mentioned it agrees with *V. Woodii*. *V. viride* is much stouter, with broad elliptical leaves, in which it agrees with the western *V. californicum*.

The differences between *V. viride* and *V. Woodii* are shown in the following table:—

V. viride.	*V. Woodii.*
Stem stout, very leafy to the top.	Stem slender, sparingly leafy.
Leaves broadly oval, sheath-clasping.	Leaves oblanceolate, only the lowest sheathing.
Panicle pyramidal.	Panicle very narrow.
Perianth yellowish green, segments ciliate-serrulate, pubescent.	Perianth greenish purple, segments entire glabrous.
Ovary glabrous.	Ovary tomentose.
Flowers 15–25 mm. broad.	Flowers 12–16 mm. broad.

The seven western species are as yet imperfectly known. *V. fimbriatum*, A. Gray, the most striking species, having fimbriate perianth-segments with two glands at the base and an obtuse, obovate, few-seeded capsule, is found only along the coast of California in Mendocino Co. We may suppose that the fimbriate character at any rate originated through a mutation. Plants belonging to *V. californicum*, Durand, and *V. speciosum*, Rydb., have broad perianth-segments, acute with a green V-shaped basal mark, or obtuse and without this mark, but the difference does not appear to be constant. *V. caudatum*, Heller, and *V. tenuipetalum*, Heller, have narrow segments, 2–3 mm. wide in the former and 1 mm. wide in the latter. The chief peculiarity of *V. caudatum* is the greatly elongated central rhachis of the inflorescence. It may be doubted whether these two species are well founded. Heller, in Muhlenbergia, i. (1905) 120, has formed a key of the seven western species he recognizes, but neither the characters nor the distribution of these species are as yet sufficiently well known to warrant further discussion. They all appear to have been derived from the *viride* type, perhaps through *V. californicum.*

18. SCHŒNOLIRION, Torr.

1. SCHŒNOLIRION CROCEUM (Michx.), A. Gray.

S. croceum, A. Gray, in Amer. Nat. x. (1876) 427.
Phalangium croceum, Michx. Fl. Bor. Am. i. (1803) 196; Nutt. Gen. i. (1818) 220.
Anthericum croceum, Schult. Syst. Veg. vii. (1829) 476.
A. Nuttallianum, Schult. *l. c.* (1829) 477.
Oxytria crocea, Raf. Fl. Tellur. ii. (1836) 26.
Ornithogalum croceum, Kunth, Enum. Pl. iv. (1843) 371.
O. Nuttallianum, Kunth, *l. c.* (1843) 372.

Georgia to Florida and Louisiana, in sandy soil.

2. SCHŒNOLIRION TEXANUM (Scheele), A. Gray.

S. texanum, A. Gray, in Amer. Nat. x. (1876) 427.
S. Michauxii, Torr. Bot. Mex. Bound. (1859) 220, partim.
Ornithogalum texanum, Scheele, in Linnæa, xxiii. (1850) 146.
Oxytria texana, Pollard, in Bull. Torr. Bot. Club, xxiv. (1897) 407.

Texas and Louisiana, on prairies.

3. SCHŒNOLIRION ALBIFLORUM (Rafin.), comb. nov.

S. Michauxii, Chapm. Fl. S. States (1860) 483.
S. Elliottii, Feay, ex A. Gray, in Amer. Nat. x. (1876) 427.
Ornithogalum croceum, Elliott, Sketch, i. (1821) 397, non Michx.
Amblostima albiflora, Rafin. Fl. Tellur. ii. (1836) 26.
Anthericum croceum, Baker, in Journ. Linn. Soc., Bot. xv. (1876) 297, non Schult.
Oxytria albiflora, Pollard, in Bull. Torr. Bot. Club, xxiv. (1897) 406.

Southern Georgia and Florida, in low pine lands.

The genus *Schœnolirion*, being one of the *genera conservanda* of the Vienna Congress, is retained. Otherwise it would be superseded by Rafinesque's

name *Oxytria*. There are only three species, *S. croceum* and *S. albiflorum* occupying much the same limited range in the south-eastern States, while *S. texanum* is farther west but overlaps *S. croceum* in Louisiana. The differences between these species may be regarded as typical specific differences, the three species forming a rather compact group. *S. croceum* differs from the other two species in having (1) bright yellow instead of white or greenish-white flowers, and (2) obtuse instead of acute or acuminate bracts. The other two species are differentiated as follows * :—

S. texanum.	*S. albiflorum.*
Leaves narrowly linear, 1–4 dm. long.	Leaves narrowly linear, 4–6 dm. long.
Scapes as long as the leaves, simple below the inflorescence.	Scapes longer than the leaves, paniculately branched above.
Pedicels 8–14 mm. long.	Pedicels 10–25 mm. long.
Perianth greenish white, 1 cm. broad.	Perianth white, 10–12 mm. broad.
Segments oblong, obtuse, 3-nerved.	Segments broadly oblong or oval, obtuse, mostly 5-nerved.
Seeds 2 mm. long.	Seeds 4 mm. long.

S. albiflorum is thus a sturdier species with longer branching scapes, longer pedicels, somewhat larger flowers, and larger seeds. These differences suggest very much the contrasts between *Œnothera Lamarckiana* and *Œ. gigas*, and this is another pair of species which may be suspected of tetraploidy or cell-gigantism. It is to be hoped that someone will make a cytological study of these three species.

Anthericum Nuttallianum, Schult., is supposed to differ from *S. croceum* chiefly in having the basal portion of the raceme interrupted, with the pedicels about an inch apart. I have seen specimens having this feature. The form should be carefully studied in the field or from a large suite of specimens to determine whether it represents a distinct species. Its segregation by Schultes is probably to be attributed to the error of Michaux in stating the inflorescence of his *Phalangium croceum* to be pyramidal.

In his *S. Michauxii*, Torrey really combined the three species of *Schœnolirion* into one.

19. HASTINGSIA, S. Wats.

The western genus *Hastingsia* is a segregate from *Schœnolirion*, to which it is not, however, closely related. It contains two species as follows :—

1. Hastingsia alba (Durand), Wats.

H. alba, S. Wats. in Proc. Amer. Acad. xiv. (1879) 242.
Schœnolirion album, Durand, in Journ. Phila. Acad. ii. III. (1855) 103.

N. California and S. Oregon.

* These characters are taken mostly from Small, Fl. S.E. Un. St. (1903) 268.

2. HASTINGSIA BRACTEOSA, S. Wats. in Proc. Amer. Acad. xx. (1885) 377.
S. Oregon, in marshes near Waldo.
Specimen: Kerbyville, Ore., *Howell*, 1884.

H. bracteosa is said to differ from *H. alba* in its longer leaves, more conspicuous bracts, flowers twice larger, and shorter stamens. The last two characters are the only constant ones in the specimens I have seen. The two species are contrasted by Howell * as follows :—

H. alba.	*H. bracteosa.*
Leaves 4–12 mm. wide, attenuate above.	Leaves 2–8 mm. wide, acuminate above.
Raceme densely many-flowered.	Raceme loosely many-flowered.
Bracts narrow acuminate.	Bracts filiform-subulate from a broad base.
Pedicels 2–4 mm. long, shorter than the bracts.	Pedicels ascending, about 4 mm. long.
Perianth-segments about 6 mm. long, oblong, obtuse, white or tinged with green or pink.	Perianth-segments 8–10 mm. long, lanceolate, acuminate, dull white.
Stamens about equalling the perianth.	Stamens half as long as perianth-segments.

This pair of species also requires a careful comparative examination. *H. bracteosa* is apparently very limited in range and may perhaps be a mutation of recent origin.

The generic characters are very well marked. The nearest relatives of *Hastingsia* are *Schœnolirion* and *Chlorogalum*. The differences from the former genus may be tabulated as follows :—

Schœnolirion.	*Hastingsia.*
Scapose herbs with bulb-like rootstocks.	Perennial herbs with scape-like sparingly branched stems from coated bulbs.
Leaves basal, often numerous.	Leaves basal, rather numerous.
Leaves very narrow, flat, rather rigid.	Leaves narrow, flat, more fleshy.
Flowers in loose, simple or sparingly branched racemes, white or yellow.	Flowers in densely many-flowered sparingly branched racemes, white or greenish.
Perianth-segments withering-persistent, not scarious, 3–5-nerved, exceeding the stamens.	Perianth-segments lax and scarious, persistent, closely 3-nerved (appearing 1-nerved), equalling the stamens.
Anthers versatile, introrsely dehiscing.	Anthers versatile.
Style short.	Style short.
Pedicels slender, exceeding the flowers and bracts.	Pedicels stout, much shorter than the flowers and bracts.
Capsule depressed globose, deeply lobed.	Capsule oblong-ovate, not deeply lobed, very shortly stipitate.

* Howell, T., in Fl. N.W. Amer. (1902) 647.

Since *Schœnolirion*, *Hastingsia*, and *Chlorogalum* form a group of three allied genera we may compare the last two as follows:—

Hastingsia.	*Chlorogalum.*
Bulbs white-coated.	Bulbs with membranous or densely fibrous coats.
Leaves narrower.	Leaves with undulate margins.
Perianth-segments lax and scarious, closely 3-nerved.	Perianth-segments at length twisted over the ovary, distinctly 3-nerved.
Style short.	Style long, deciduous.
Flowers white or greenish, in densely many-flowered sparingly panicled racemes.	Flowers white, pinkish or purplish, in loose paniculate racemes.
Anthers versatile.	Anthers versatile.

Of these three genera, *Schœnolirion* occupies the Southern States from Florida to Texas, while *Chlorogalum* occurs in the greater part of California, and *Hastingsia* is found in Northern California and adjacent Oregon. It is difficult to trace the steps by which these genera have become separated. *Hastingsia* appears to be more closely related to *Schœnolirion* despite its western position. In such cases, as in those of bifurcated genera with eastern and western species, it seems necessary to assume that the ancestors originally occupied a more northerly position and that the eastern and western forms became separated as they were driven southward by the ice. In the central plains area, plants of this group failed to find suitable habitats, at least after the plains took on their present aspect, and so only eastern and western forms, variously modified, have persisted to the present time.

Another monotypic genus, represented by *Hemiphylacus latifolius*, S. Wats.*, in Northern Mexico, belongs with this group. Among its peculiarities the most interesting are (1) the tuberous roots, (2) the filaments adnate to the perianth-segments for half their length, (3) only the inner and shorter ones bearing anthers, which are versatile, rounded, introrse, and (4) the scarious 1-nerved perianth-segments.

20. CHLOROGALUM, Kunth.

1. Chlorogalum pomeridianum (Ker), Kunth.

C. pomeridianum, Kunth, Enum. iv. (1843) 682.
C. divaricatum, Kunth, *l. c.*; Torr. Bot. Mex. Bound. (1859) 218, t. 60.
Scilla pomeridiana, DC. in Redouté, Lil. (1816) t. 421.
Anthericum pomeridianum, Ker, in Bot. Reg. (1821) t. 564.
Phalangium pomeridianum, D. Don, in Sweet, Hort. Brit. ed. 1, 416 (1827).
Ornithogalum divaricatum, Lindl. Bot. Reg. xxviii. (1842) t. 28.
Laothoe pomeridiana, Rafin. Fl. Tellur. iii. (1836) 53.
L. divaricata, Greene, Leaflets Bot. Obs. i. (1904) 91.

California, from Mendocino Co. southward to San Bernardino Co.

* In Proc. Amer. Acad. xviii. (1883) 164.

2. Chlorogalum parviflorum, S. Wats. in Proc. Amer. Acad. xiv. (1879) 243.

Laothoe parviflora, Greene, Leaflets Bot. Obs. i. (1904) 91.

S. California, San Diego Co.

3. Chlorogalum angustifolium, Kellogg, in Proc. Calif. Acad. ii. (1863) 105, t. 30.

Laothoe angustifolia, Greene, Leaflets Bot. Obs. i. (1904) 91.

Middle California, Sacramento Valley, and Mendocino Co.

4. Chlorogalum purpureum, T. S. Brandegee, in Zoe, iv. (1893) 159.

Laothoe purpurea, Greene, Leaflets Bot. Obs. i. (1904) 91.

California, Coast Range, Monterey Co. southward.

The genus *Chlorogalum* contains four species and is practically confined to California. The following key, compiled by Mr. C. H. Thompson, shows the nature of the specific differences :—

A. Bulb large, thickly coated with coarse brown fibres; perianth-segments narrowly ligulate, spreading widely from the base in the open flower. *C. pomeridianum* (Ker), Kunth.

B. Bulbs smaller, with membranaceous coat; perianth-segments spreading from above the base.

a. Perianth-segments oblong-ovate; pedicels as long as or longer than the perianth; flowers purplish blue. *C. purpureum*, T. S. Brandegee.

b. Perianth-segments oblong-lanceolate; pedicels very short.

α. Flowers pinkish; ovary broad and obtuse. *C. parviflorum*, S. Wats.

β. Flowers white with yellowish-green lines; ovary oblong-ovate, acutish above, short stipitate. *C. angustifolium*, Kellogg.

In *C. pomeridianum* the branches are spreading, the stems dark brown, and the leaves remarkably undulate. *C. angustifolium* differs in having narrow linear-lanceolate leaves, slightly undulate, and a bulb which is ovo-conic rather than long-ovate.

C. pomeridianum and *C. angustifolium* apparently have much the same range in central California, the latter occurring chiefly farther inland in the Sacramento Valley, while the former extends farther northward into Oregon. The other species are more local in distribution and probably more recent in origin, as they are in discovery. *C. parviflorum* occurs in the extreme south, in San Diego Co., and *C. purpureum* in the Coast range of Monterey Co.

This would be an interesting genus for experiments in cultivation, but until such are instituted it is superfluous to comment further on the specific differences exhibited, except to say that there is an unusual range of colour variation for so small a genus.

21. ODONTOSTOMUM, Torr.

A monotypic genus of western North America.

Odontostomum Hartwegii, Torr. in Pacif. R. R. Rep. iv. (1856) 150, t. 24; Baker, in Journ. Linn. Soc., Bot. xi. (1870) 436.

In California, from Shasta Co. to Napa and Amador Co., chiefly in the Sacramento Valley. Said to be rare.

Specimens: Near Napa, Calif., *A. W. Robinson*, 1892. Redding, Shasta Co., California, *A. A. Heller*, May 26, 1905.

Odontostomum, while most nearly related to the group of Chlorogaleæ, is rather isolated, especially in flower-structure, though the foliage and habit clearly resemble that group. Of the three genera it is nearest *Chlorogalum*. The flowers are small and yellowish and the base of the stem forms a fibrous-coated corm. The deciduous perianth of *Odontostomum* in the form of a cylindrical 12-nerved tube, bearing in salver-form and finally reflexed the 5-nerved segments, is a new feature in this group. Our experience of mutations is as yet too limited to permit an understanding of the way in which the development of this organ took place. The perianth-segments are obtuse and the three outer ones cucullate at the tip.

Another striking peculiarity is in the stamens. There are 6 stamens with subglobose anthers at the summit of short filaments, and alternating with them are 6 staminodia, the whole forming a ring at the top of the perianth-tube*. In this feature *Odontostomum* bears some resemblance to the Mexican *Hemiphylacus*, though in the latter there are only 3 stamens and 3 (longer) staminodia. Evidently several definite variations occurred to produce the *Odontostomum* flower, but what their sequence has been it is impossible to say. In connection with the stamens there has evidently been a loss mutation in *Hemiphylacus* (see p. 170), while there must have been a positive mutation in *Odontostomum*.

The fact of parallel mutations introduces an important principle into conceptions of phylogeny. Thus *Chlorogalum* and its relatives have versatile anthers, but it is not necessary to assume that this feature has been handed down from a common ancestor of *Chlorogalum* and *Lilium*. It is much more probable that the versatile condition has been developed independently in the Chlorogaleæ and the Lilieæ through parallel mutations.

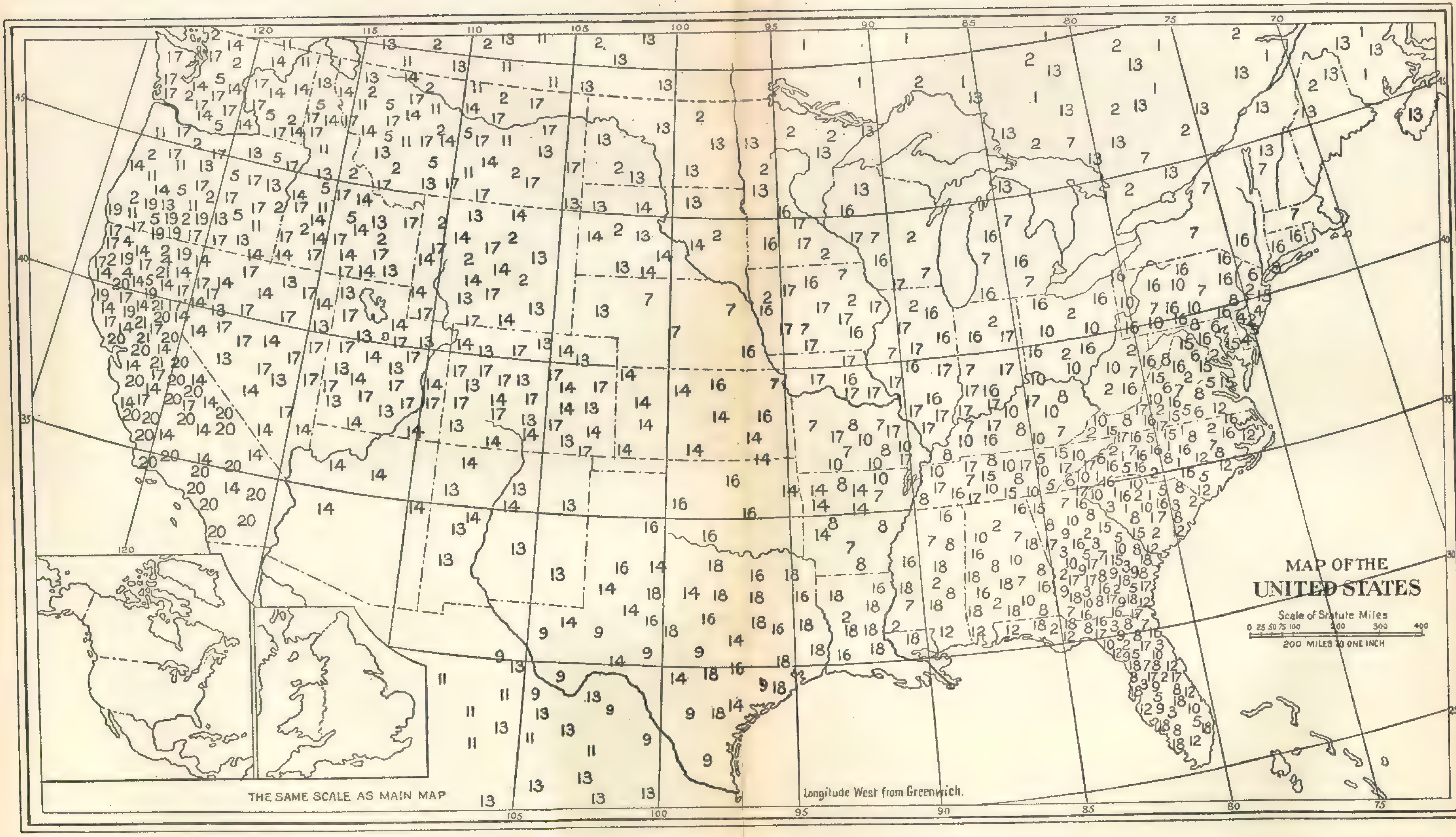
KEY TO MAP, PLATE 5.

Genera of *Melanthaceæ*.

1. Tofieldia. 2. Triantha. 3. Pleea. 4. Narthecium. 5. Xerophyllum. 6. Helonias. 7. Chamælirium. 8. Amianthium. 9. Schœnocaulon. 10. Stenanthium. 11. Stenanthella. 12. Zigadenus. 13. Anticlea. 14. Toxicoscordion. 15. Oceanorus. 16. Melanthium. 17. Veratrum. 18. Schœnolirion. 19. Hastingsia. 20. Chlorogalum. 21. Odontostomum.

* According to Jepson [in Fl. W. Mid. Calif. (1901) 114], "the stamen opposite the lower outer segment stands alone and faces the remaining 5, which approximate each other by their filaments on the upper side of the flower."

JOURN. LINN. SOC., BOT. VOL. XLIV. PL. 5.



DISTRIBUTION OF NORTH AMERICAN MELANTHACEÆ.

Spolia Runiana.—III. The Distribution of certain Diatoms and Copepoda, throughout the year, in the Irish Sea. By W. A. Herdman, F.R.S., F.L.S., Professor of Zoology in the University of Liverpool.

(With 21 Text-figures.)

[Read 1st November, 1917.]

Part of the work * of the yacht 'Runa' for some years previous to 1914 consisted in taking periodic samples of the marine plankton at various localities around Port Erin, at the south end of the Isle of Man, during the two most interesting times in the annual cycle—viz., spring (March–April) and autumn (July–September). During the remaining months, when the yacht was not in commission, plankton gatherings in Port Erin bay were taken with great regularity at the rate of six in the week, three at a time on two occasions per week, two of the three hauls being horizontal and the third vertical. This systematic plankton survey has been continued for fully 10 years (1907–1917 inclusive), and over 5000 † samples have been collected and examined. The general results of this intensive study of the plankton of a central area of the Irish Sea have been given in a series of reports ‡ drawn up in collaboration with Mr. Andrew Scott, A.L.S., and others, and published by the Lancashire and Western Sea-Fisheries Committee; but the material and statistics collected still contain much information which has not yet been made use of. It is proposed in the present communication § to deal with the records of the occurrence throughout the year in our district of a few of the most abundant of the Diatoms and the Copepoda which make up the bulk of the phytoplankton and of the zooplankton respectively at those periods of the year when they are most abundant. At the time of the spring maximum (usually in April or May) a small silk tow-net hauled for about 15 minutes through about half-a-mile of the surface water of the Irish Sea will usually catch some millions of individual Diatoms (up to a couple of hundred millions ‖ on occasions), constituting probably, on the average, some 999,999 out of each million of organisms in the gathering ¶. This is almost

* For Parts I. and II. of "Spolia Runiana" see Journ. Linn. Soc., Zool. xxxii. p. 163 (1913), and p. 269 (1914).

† More precisely 5116, to the end of 1916.

‡ Trans. Biol. Soc. Liverpool, xxii. (1908) to xxxi. (1917).

§ I wish to acknowledge, with thanks, the help I have received in the preparation of these plankton records from Mr. Andrew Scott, A.L.S., and from my secretary, Miss H. M. Lewis, B.A. Mr. Scott took for me the excellent photo-micrographs of the plankton from which most of the illustrations have been reproduced.

‖ Estimated by counting measured samples.

¶ The average of a number of cases where smaller, but still very large, hauls of Diatoms were taken is—Diatoms=about 99 per cent. of the total organisms present.

a pure sample of Diatoms—a "monotonic phytoplankton." Similarly, when the zooplankton is at its height in late summer (usually September) the same net may contain almost a pure gathering of Copepoda numbering some tens to hundreds of thousands of individuals (up to 214,000), and making up perhaps 999 out of every thousand organisms present—a "monotonic zooplankton." But we may still regard the gathering as a zooplankton if over 50 per cent. of the organisms are animals—on account of their greater bulk.

Moreover, these very abundant Diatoms and Copepoda belong in each case to very few species, so that one can select about half-a-dozen species of Copepoda which constitute by far the greater part of the summer zooplankton, and about the same number of Diatoms which similarly make up the bulk of the spring phytoplankton. These few species, belonging to these two very widely separated groups, thus come to be the most significant organisms

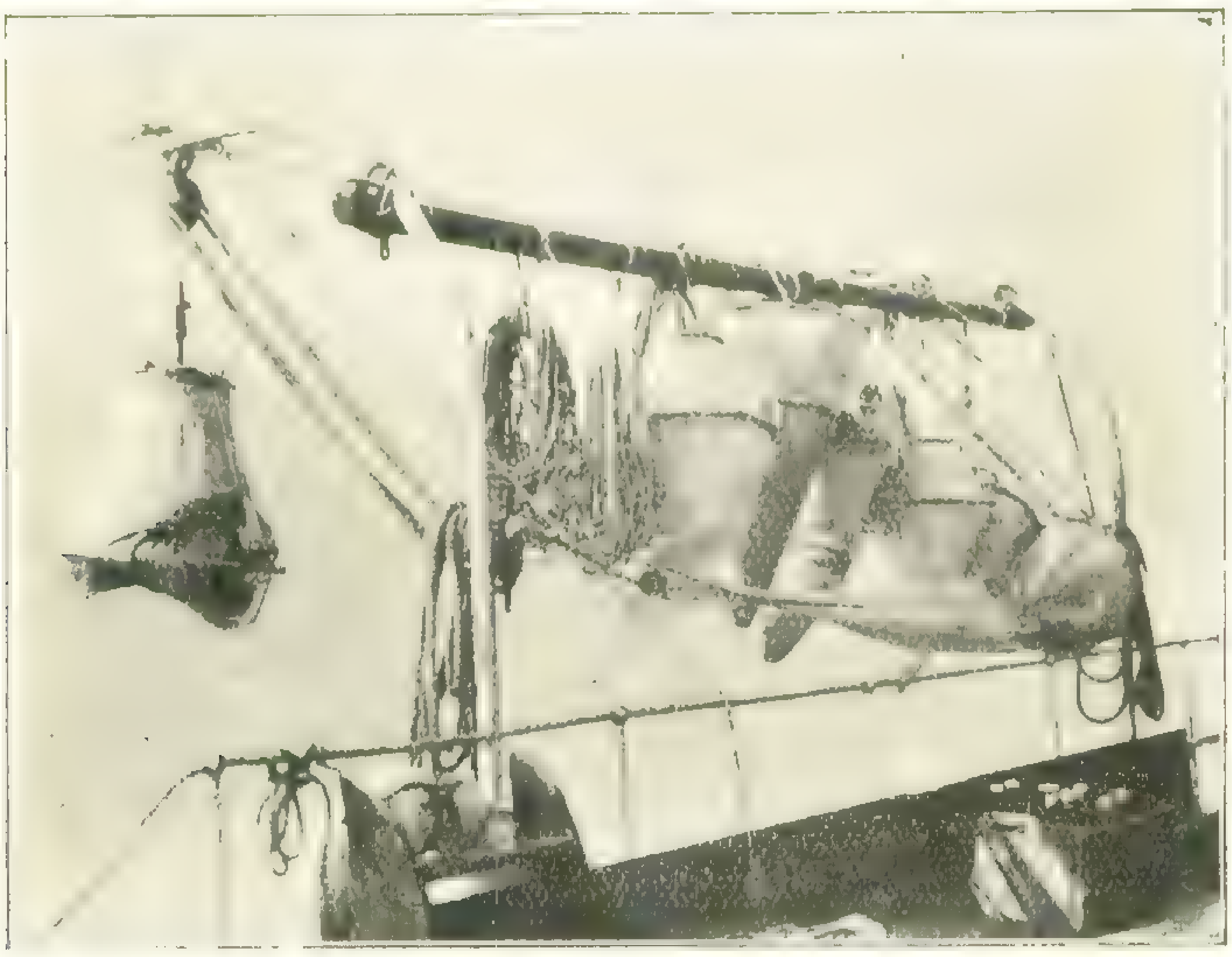


FIG. 1.—"Hensen," "Nansen," "Funnel" and other plankton nets drying after use on the yacht.

in relation to the annual metabolic cycle of our seas and the food-supply from our coastal fisheries. Consequently it is of both scientific and economic importance to obtain such data as seem possible from our long series of observations, extending over a decade, as to the occurrence of these dominant factors in the plankton. No doubt there are exceptional years with unusual occurrences which will have a disturbing effect, but the ten or eleven years' results ought to give us an average of some value.

We have endeavoured, in our work from the yacht, as the result of many experiments, to make use of a standard net in a constant manner so that the hauls should be approximately comparable. Our two horizontal tow-nets of fine-meshed miller's silk (No. 20 and No. 9) measure 35 cm. (about 14 inches)

in diameter at the mouth, and are in our weekly gatherings throughout the year hauled through a definite course in the open water of Port Erin bay. The two together ("coarse" and "fine" nets) constitute a "standard haul." The gatherings taken outside the bay during the periods of the vernal and autumnal plankton maxima were made with the same nets as in the bay, at fixed "stations" respectively three and five (and on a few occasions ten) miles from land *.

In addition to these standard hauls many others were taken with special nets, such as the closing "Petersen-Hensen" and "Nansen," the "shear-net" and "funnel-nets," usually at depths of 5 to 30 fathoms, and on occasions down to 60 fathoms out in the deep central valley between the Isle of Man

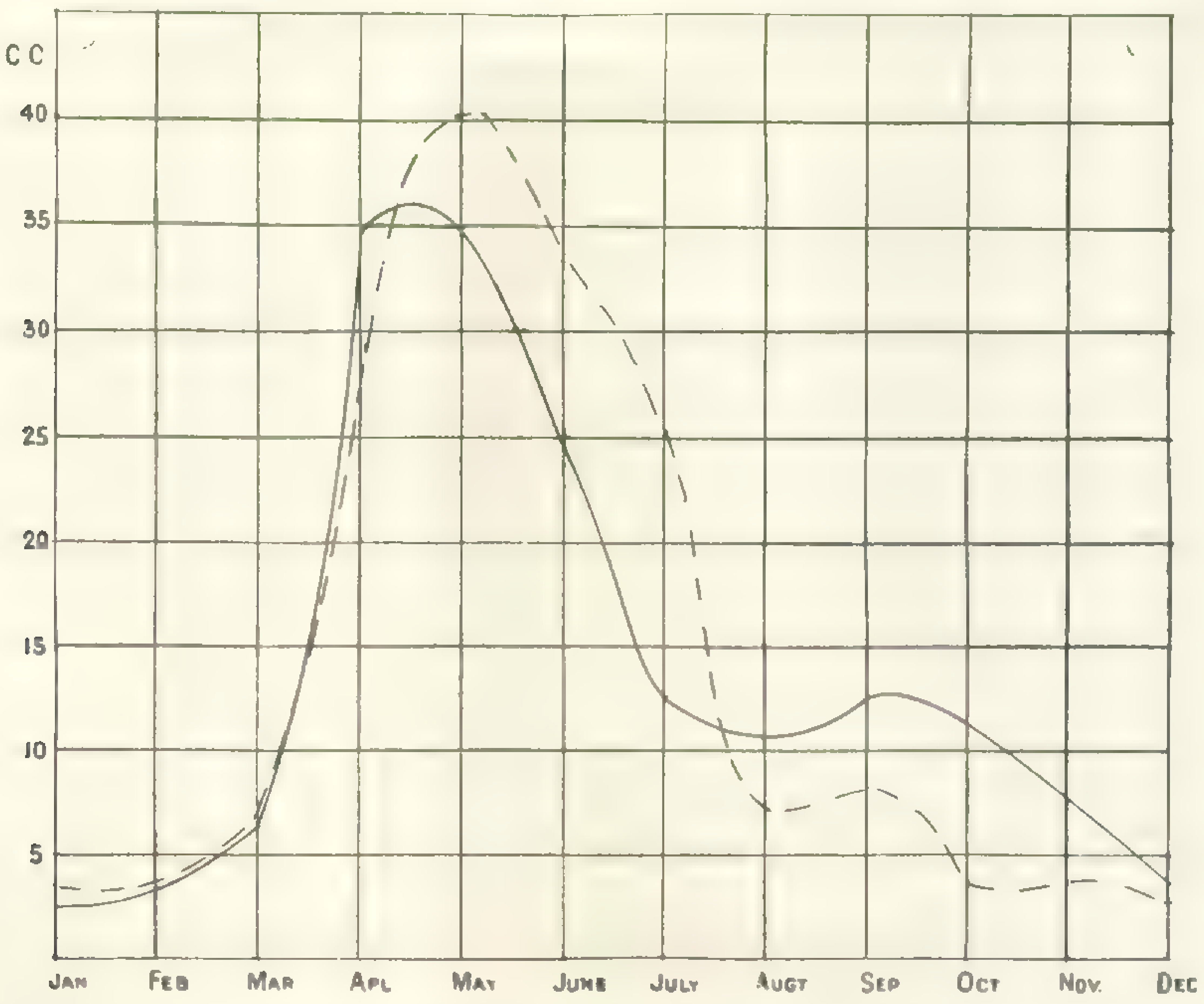


FIG. 2.—Typical Irish Sea plankton curves for the years 1913 (dotted line) and 1914 (whole line).

and Ireland. Figure 1 gives a general view of the various nets used on one of our plankton cruises. Temperatures, surface and deeper, weather observations and water-samples were also taken systematically †.

The plankton gatherings when taken are at once treated with formol to kill and fix the organisms and prevent further changes. They are then placed (at the Port Erin Biological Station) in graduated cylinders, and after some hours, when the material has fallen to the bottom and the superjacent fluid is clear, the quantity of plankton in cubic centimetres is recorded. The fixed plankton is then concentrated and preserved in

* Determined by cross-bearings, and by distance run calculated from the engines.

† For further particulars as to methods, see the earlier reports published by the Lancashire and Western Sea-Fisheries Committee.

5 per cent. formol, and is re-measured it may be weeks later when submitted to detailed examination. It is this last more accurate measurement that has been made use of for calculations and curves. The first estimation of the volume is only taken in case some accident happens later; but we have been very fortunate in that respect: we have only lost about 10 gatherings in the 10 years out of over 5000 samples. Figure 2 shows typical plankton curves for the years 1913 (dotted line) and 1914, taken from the recorded monthly averages of the plankton hauls. As an example of the height to which individual hauls may rise in spring, I may quote from our records of this year that on April 18th, 1917, the standard haul measured 165 c.c., and on April 19th 150 c.c., and consisted mainly of *Chætoceras*.

Our confidence that these samples are adequate and representative receives support from the fact that the same organisms are recorded in much the same quantities year after year, and that practically no new forms turn up. Mr. Andrew Scott, A.L.S., who has made a detailed microscopic examination of all the material for the purpose of determining the species, has met with none new to science. Some rare species previously unknown in British seas, such as the Norwegian Copepod *Microcalanus pusillus*, Sars, which appeared first in our deeper nets in the summer of 1907, and the Indo-Pacific Diatom *Biddulphia sinensis*, Grev., have occurred; but throughout the series of over 5000 gatherings, extending over nearly every week of 10 years, no species actually new to science has been determined from the macroplankton. The various new Copepoda which have been described from time to time from our work at Port Erin have all been bottom-living forms obtained by dredging. This is, so far, a satisfactory result of our work, as it seems to indicate that probably all the pelagic species of Copepoda in our sea are now known. It is not the rare species that are of most interest. They may have an interest of their own—morphological or distributional—but for my present purpose it is the common species that are of most importance, those species which by their abundance in nature play their part in providing fish-food for man or in affecting the public health either by keeping the sea clean or by causing plagues.

For the purpose then of arriving at some conclusion as to the distribution throughout the year of these really significant organisms, I have picked out from our records the following six species of Copepoda as being undoubtedly the most abundant and economically the most important representatives of that section of the plankton:—*Oithona helgolandica* (= *similis*), *Pseudocalanus elongatus*, *Acartia clausi*, *Temora longicornis*, *Paracalanus parvus*, and *Calanus finmarchicus*. These are all cases of genera where there is only one species in our seas (e.g., *Calanus*) or only one common species (e.g., *Oithona*), so that we are dealing with half-a-dozen very distinct forms, and there can be no doubt as to what is in question even if the genus only is referred to.

When we turn to the Diatoms the case is rather different. There several of the more prominent genera are represented by a number of common species, and moreover some of the species are closely related, and variable, so that doubts may arise as to the exact identifications, and authorities may differ as to the relative proportions in which certain species or varieties of, say, *Chætoceras* or *Biddulphia* are present in the plankton. Under these circumstances I have considered it will best serve my purpose, which is a general and economic rather than a detailed speciographic one, if I deal with generic titles only, grouping together for example all the species of *Chætoceras* that may occur under that one name. I have chosen the following genera as being the most important representatives of the Diatoms in our plankton :—*Biddulphia*, *Chætoceras*, *Coscinodiscus*, *Rhizosolenia*, *Thalassiosira*, *Guinardia*, and *Lauderia*. In some of these genera (e.g., *Guinardia* and *Lauderia*) as in the case of the Copepoda there is only one possible species in question, in *Biddulphia* it is in most cases only the species *B. mobiliensis*, but in others (e.g., *Chætoceras, Coscinodiscus*, and *Rhizosolenia*) there are usually several allied species occurring together in profusion in any large gathering of the genus.

I may add that our commonest species in the Irish Sea off Port Erin are not necessarily those that are most abundant in other seas of North-West Europe. For example, in the Baltic near Kiel, according to Lohmann, the most abundant Diatom is *Skeletonema costatum*, a comparatively rare form in our plankton, and George Murray similarly found that to be the commonest form he had met with in a plankton survey of some of the more sheltered lochs of the West of Scotland. It is, however, one of the minuter forms which readily escapes notice, and may to a considerable extent pass through the meshes of the net.

Then again, in July 1911, in Upper Loch Torridon, on the West Coast of Scotland, I got a haul of 334,000,000 *Nitzschia delicatissima*, which is rare with us in the Irish Sea, but is apparently more abundant at Plymouth.

I think it probable, however, that our Port Erin results will be found to hold good for the more open sea-water of high salinity * around the British Isles. A valuable paper which appeared recently on the Plankton of Plymouth Sound, by Dr. Marie V. Lebour †, while dealing mainly with the more minute Protozoa and Protophyta which escape the tow-net and can only be obtained by centrifuging samples of water, gave also some records of the occurrence of some of the larger forms which enables a comparison to be made between the plankton conditions in the English Channel and in the northern part of the Irish Sea.

* The salinity off Port Erin averages about 34·2 per mille. Its range for April, May, and June in the year when we took the most complete series of observations is from 34·02 to 34·4 per mille.

† Journ. Mar. Biol. Assoc. vol. xi. 2 (1917), p. 133.

There are certain differences in detail. For example, the total Diatom curve at Plymouth has three maxima or crests, in April, August, and October. At Port Erin the curve has only two crests, a much greater maximum in spring and a variable and smaller one in autumn, while Diatoms are usually wholly absent in August.

On the other hand, there is a general agreement in regard to the distribution throughout the year of many of the more abundant organisms. For example, amongst Diatoms *Coscinodiscus* is a winter and early spring form, *Biddulphia* flourishes throughout the winter from November to April or May, *Rhizosolenia* is a summer form having its maximum in June, while *Chætoceras* and *Lauderia* have two maxima, the one in spring and the other in autumn, in the English Channel and the Irish Sea alike. Amongst Copepoda there seems to be a general agreement along with a certain amount of difference in detail which will be referred to below when discussing the species.

I may recall that in November 1910 I read a paper before this Society * in which I made a comparison between the summer (July) plankton on the West Coast of Scotland and that of the Irish Sea, showing that in some of the deep fjord-like highland sea-lochs green-coloured phytoplankton can be obtained even in the height of summer, while a zooplankton may be found living in abundance a few miles away. This, of course, would be impossible in the Irish Sea, where a zooplankton and a phytoplankton do not occur simultaneously.

DIATOMS.

The seven generic forms I have selected for consideration taken together make up nearly the whole of the Diatom plankton of the year. No other genus occurs in anything like such profusion as these. In April, for example, when the Diatoms are usually at their climax, all the remaining genera (at most 10 or 12) taken together make up only about one-thousandth, or less, of the whole. Moreover, these common Diatoms often attain their greatest profusion successively, not simultaneously, so that single genera, or it may be single species of a genus, make up on occasions the bulk of the phytoplankton. For example, in May 1916 the month's average haul of Diatoms was 7,171,789, while the average for the genus *Chætoceras* taken alone was 6,947,333, leaving only 224,456 as the average of all the rest of the Diatoms. On the last two individual hauls, taken on May 25th and 29th, the actual numbers were as follows:—

Chætoceras alone	24,094,500 ...	19,461,600
C. sociale alone	23,936,000 ...	19,396,000
All other Diatoms together...	166,300 ...	228,900

So that on these occasions, and they are examples of many, one species makes up nearly the whole of the plankton.

* Journ. Linn. Soc., Zool. xxxii. (1913) p. 23.

The maximum on the Diatom curve ranges from March to May. In 1907 it was in March, in 1908 in May, and in 1909 in April. In some years the Diatom maximum may be divided into two parts, an earlier due mainly to *Chætoceras* and *Thalassiosira*, and a later in June due to *Rhizosolenia* and *Guinardia*. A common order of succession for the species which contribute most largely to the Diatom maxima is—*Biddulphia mobiliensis* and *Coscinodiscus radiatus* in early April, *Chætoceras debile* in late April, *Chætoceras sociale* in May, *Chætoceras teres* and *Rhizosolenia Shrubsolei* in early June, and *Rhizosolenia* (several species) and *Guinardia* in later June. The autumn Diatom maximum is constituted mainly in the Irish Sea by *Chætoceras subtile* and *Rhizosolenia semispina*. Certain species of most of the genera we are dealing with are commonly regarded as "oceanic" in the sense that they are characteristic of the open sea, although they may occasionally be carried in shore and so form a part of the coastal plankton; while other species are "neritic," having their origin and their home in coastal waters and not being found normally in the open ocean. For example, *Chætoceras densum*, *C. boreale*, *Coscinodiscus radiatus*, and *Rhizosolenia semispina* are supposed to be oceanic; while *Biddulphia mobiliensis*, *Chætoceras subtile* (and other species), *Coscinodiscus concinnus*, *Rhizosolenia setigera*, and *Lauderia borealis* are probably neritic. Other species of these genera are of doubtful position in this classification, or it may be are "panthalassic" or equally at home in both regions.

Biddulphia.

This is a winter and early spring group of Diatoms, generally appearing in September or October, becoming more abundant in November and reaching a maximum in March or April. It dies off during May, and is practically absent in June, July, and August.

The species, or forms, that occur in our plankton are *Biddulphia mobiliensis* (? *B. regia*) and *B. sinensis* (fig. 3). This is one of the cases where there is some difference of opinion as to the validity of species. Whether *B. regia* is only a form of *B. mobiliensis*, and what is the exact relation of *B. sinensis* to the others, has been and may still be a matter of discussion. Specimens can be picked out that seem distinct and characteristic, but others occur in nature that are intermediate and possibly abnormal *.

B. sinensis is an exotic, oceanic form which, according to Ostenfeld, made its appearance at the mouth of the Elbe in 1893, and spread during successive years in several directions. It appeared suddenly in our plankton gatherings at Port Erin in November 1909, and has been present in abundance each year since. Ostenfeld, in 1908, when tracing its spread in the North Sea, predicted that it would soon be found in the English Channel. Miss Lebour, who has recently examined the old plankton gatherings at the Plymouth

* See forms figured in Trans. Biol. Soc. Liverpool, xxvii. (1913) p. 210.

Laboratory, finds that as a matter of fact this form did appear in abundance in the collections of October 1909, within a month of the time when according to our records it reached Port Erin. Whether or not this species was brought accidentally by a ship from the far East, there is no doubt that it was not present in our Irish Sea plankton gatherings previous to 1909, but has been abundant since that year, and has completely adopted the habits of its English relations—appearing with *B. mobiliensis* in late autumn,

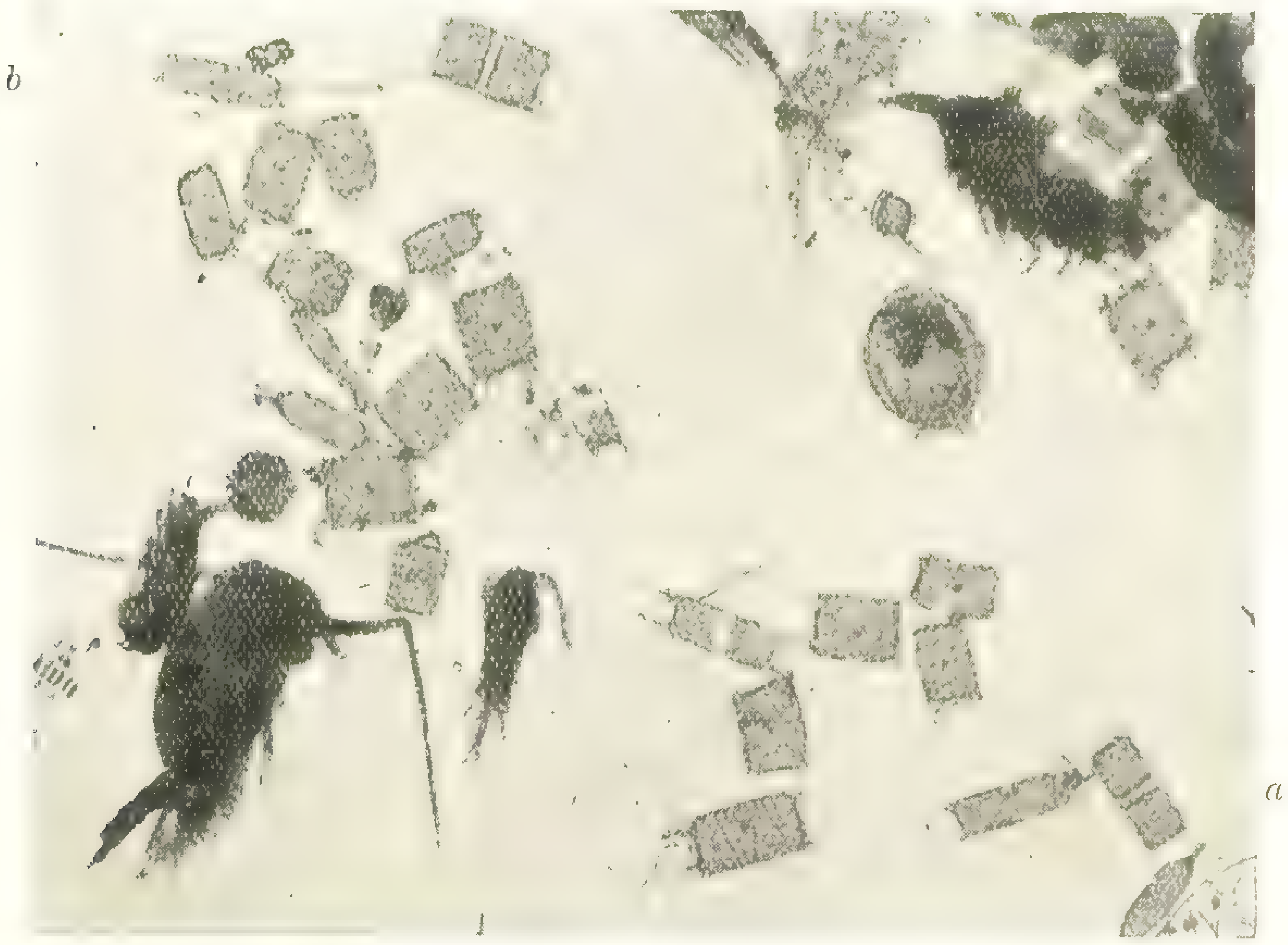


FIG. 3.—Photo-micrograph of a plankton preparation showing (*a*) *Biddulphia mobiliensis*, forma "*regia*," and (*b*) *B. sinensis*.

persisting during the winter, reaching a maximum in spring, and dying out before summer. *Biddulphia* is generally the first Diatom to show a marked increase in early spring, and is responsible for the moderate rise in the curve which takes place in February or March.

Our largest records of *Biddulphia* are as follows :—

From three hundred thousand to over six hundred thousand per haul on several occasions between middle of March and middle of April in 1910 and 1911, and towards end of April and beginning of May, 1916.

From three hundred thousand to over seven hundred and fifty thousand on ten occasions between November 10th and 27th, 1911, 1914, and 1915.

The highest monthly averages in the early spring months occur as follows :—

February	...	in 1907 and 1912.
March	...	in 1910, 1911, 1914, and 1915.
April	...	in 1908, 1909, 1913, and 1916.

A second, usually slighter, maximum occurs in November, when the numbers are higher than in December and January ; but on three occasions

(1911, 1914, and 1915) in our ten years the November monthly average is the highest in its year. Moreover, two of these November records, viz., 341,231 in 1911 and 406,100 in 1914, are the highest in the whole series. So *Biddulphia* may be regarded as characteristic of the late autumn (November) as well as the early spring plankton.

Coscinodiscus.

The more abundant species that our records deal with are *Coscinodiscus concinnus*, *C. Grani*, and *C. radiatus*. They are mainly winter and spring forms, the maximum of the genus occurring always in our experience in either March or April. *Coscinodiscus* (fig. 4) agrees very closely with *Biddulphia* in its distribution throughout the year, beginning in late autumn, maintaining its position throughout the winter, increasing in January or

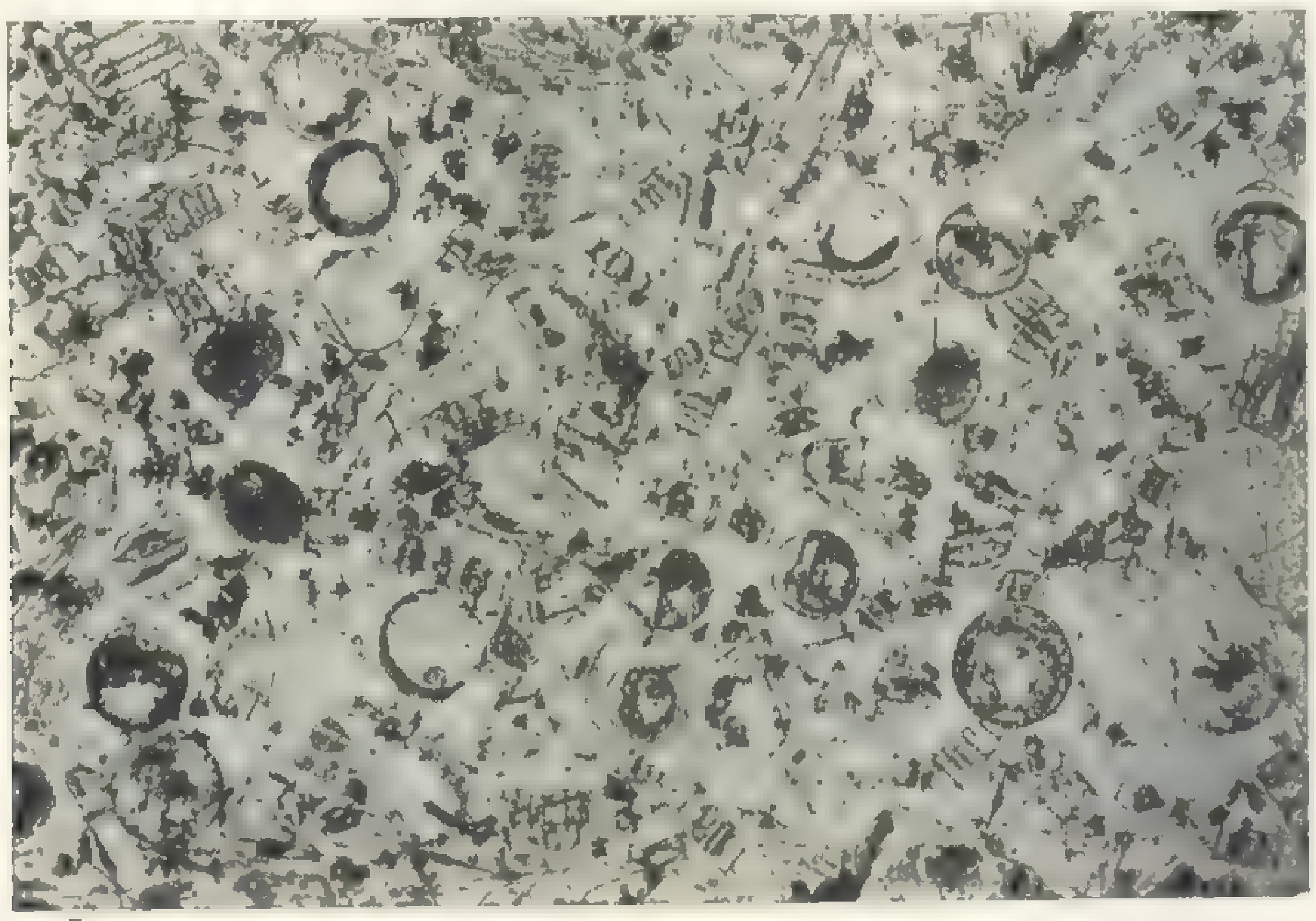


Fig. 4.—Photo-micrograph of an early spring phytoplankton consisting mainly of *Coscinodiscus* and *Biddulphia*.

February, and then more rapidly in March and April, and dying away before the height of the summer; but it sometimes continues to be present in small quantities further into the summer months than is the case with *Biddulphia*.

The presence of *Coscinodiscus* in quantity in the spring plankton is easily seen through a glass jar with the unaided eye, as the little rounded drum-like cells give a characteristic granular appearance to the gathering.

Our largest records of *Coscinodiscus* are :—

From four to five hundred thousand per haul on several occasions between middle of March and middle of April, 1911, 1912, 1913, 1915, and 1916.

About nine hundred thousand on several occasions at end of April 1914.

From one million to close on five millions on two occasions in middle of April 1915.

So *Coscinodiscus* may outrival its companion form *Biddulphia* at the time of the vernal maximum, but does not attain to such high numbers in late

autumn. The October and November monthly averages never, in our series of years, come anywhere near the averages for March and April.

Both *Biddulphia* and *Coscinodiscus* seem to be slightly later in their maxima in the Irish Sea than in the English Channel, judging from the Plymouth records.

In the years 1907 to 1912, inclusive, the highest monthly averages (March and April) for *Coscinodiscus* run in general about 100,000. In 1913 and 1916 they are close on 200,000, in 1914 over 300,000, and in 1915 there is a sudden jump, in April, to over 840,000. The other months of that year do not show unusually high numbers.

CHÆTOCERAS.

The chief species of this genus in our Irish Sea plankton are *Chætoceras boreale*, *C. contortum*, *C. criophilum*, *C. debile*, *C. decipiens* (fig. 6), *C. densum*,

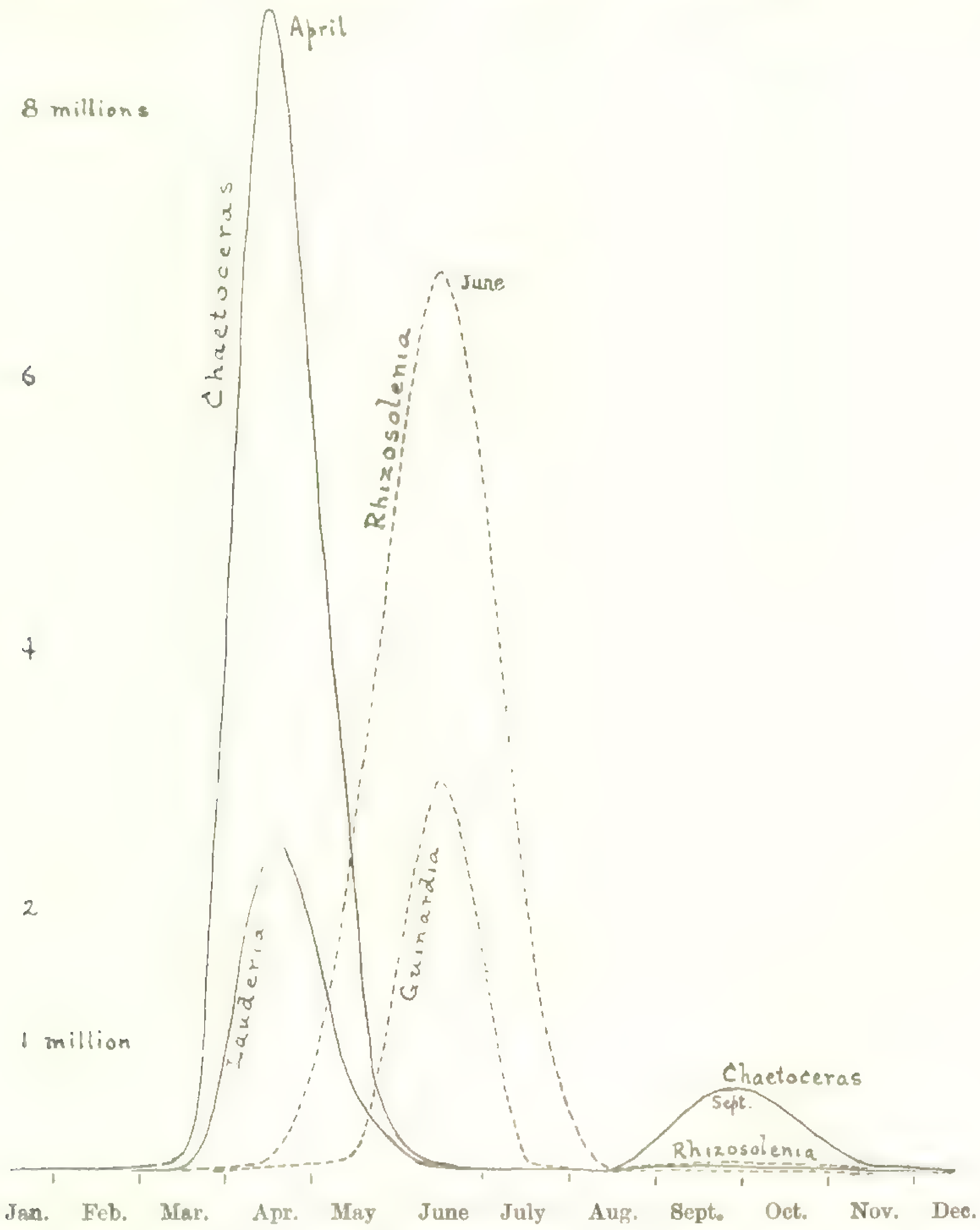


FIG. 5.—Curves of the more important Diatoms of the April and June maxima.

C. diadema, *C. sociale*, and *C. teres*. Of these, *C. boreale*, *C. criophilum*, and *C. decipiens* are Arctic oceanic forms, *C. densum* is a temperate oceanic or

Atlantic species, and all the rest may be classified as temperate neritic. Some of these (*C. criophilum*, *C. debile*, *C. decipiens*, *C. sociale*, and *C. teres*) are spring forms with a maximum in April or May, while *C. boreale* and *C. densum* are autumn species having their maxima in September or October. Consequently the genus is well represented throughout a considerable part of the year, and the numbers are very high in April and May, and sometimes also in September and October (see curve, fig. 5). A few of our highest records for the genus, giving the nearest million in each case, are :—151 millions on May 4th, 1914, 95 millions on April 29th, 1912, 68 millions on May 16th, 1911, 49 millions on April 22nd, 1910, and 44 millions on May 19th, 1911. The highest record we have for the autumn species is 30 millions on September 26th, 1912. On May 16th, 1911, *C. debile* contributed 30 millions and *C. sociale* 12 millions to the total in the haul ; and on May 4th, 1914, *C. debile* gave 148 out of the 151 millions

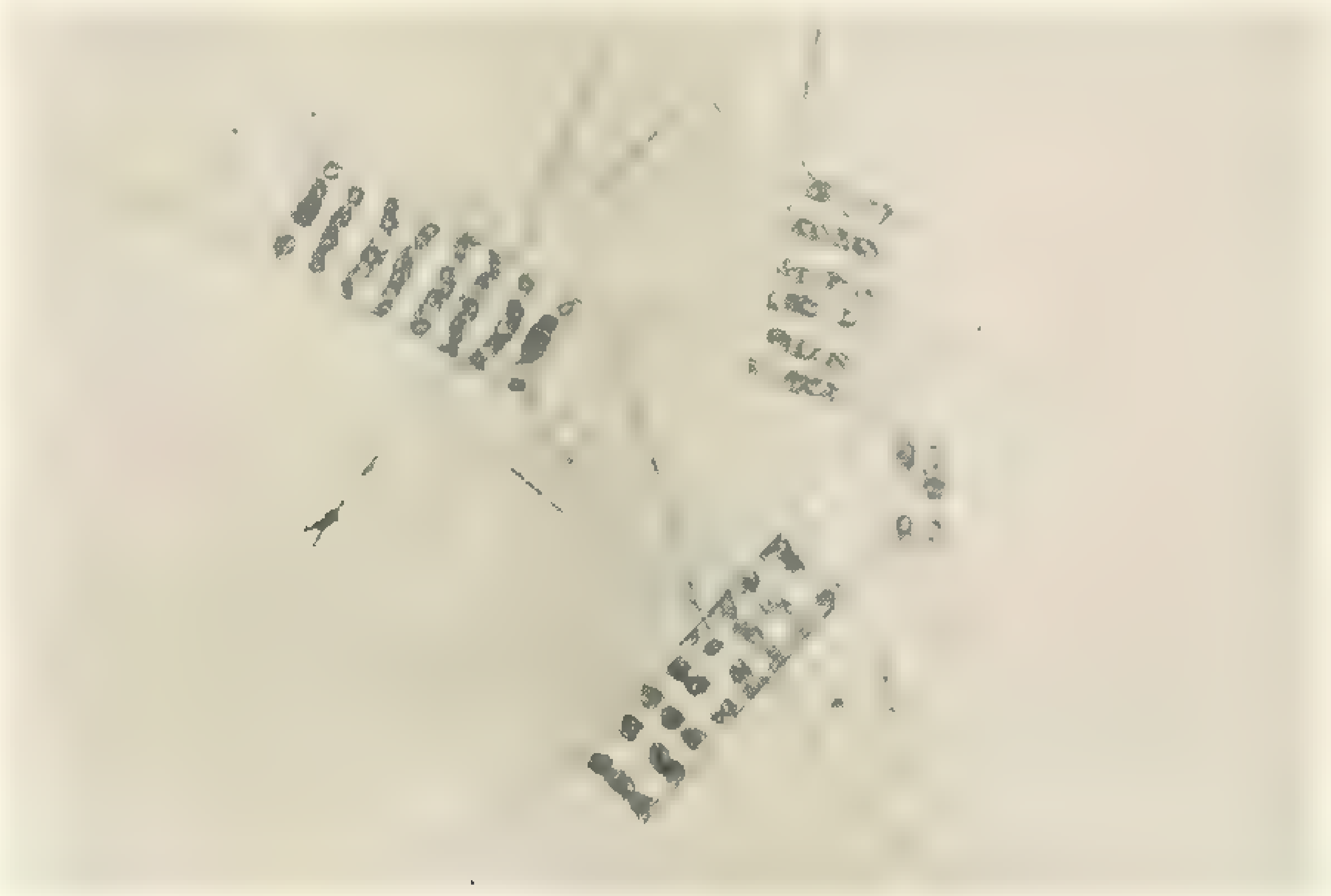


FIG. 6.—*Chætoceras decipiens*, showing the active winter growth.
From a photo-micrograph by A. Scott.

present. If we examine the records of the separate species for the year 1914 as an example, we find that *C. contortum* has an average of 62,700 per haul in May, *C. debile* an average of 867,878 in April and 18,972,800 in May (the record), *C. decipiens* an average of 821,311 in April and 321,050 in May, *C. sociale* an average of 1,229,500 in May, *C. teres* an average of 577,867 in April ; while of the autumn species *C. boreale* has an average of 53,200 in September and 54,644 in October, and *C. densum* has 151,120 in September and 100,624 in October. *C. debile* and *C. decipiens* were also very abundant that October.

The highest monthly averages for *Chætoceras* fall as follows during our ten years :—

March	...	in 1907.
April	...	in 1909, 1910, and 1912.
May	...	in 1908, 1911, 1913, 1914, 1915, and 1916.

The highest average is nearly 23 millions, in May 1911. None of the September and October averages run as high as those in spring, and only two reach millions, viz., 3,956,047 in October 1911, and 7,702,658 in September 1912. The years 1911 and 1912 had high numbers of *Chætoceras* throughout many of the months*. There are no months in the ten years when *Chætoceras* was totally unrepresented; but July and August show the lowest averages—the lowest of all being only six individual cells in August 1907.

Lauderia.

We have only the one species, *Lauderia borealis*, Gran (fig. 7), in our records. It is a late spring or early summer form, occurring generally from March or April to June or July, with a later, smaller, occurrence in autumn. It is sometimes present in large quantities, *e. g.*, 20,064,000 on April 22nd, 1910; 12½ millions on April 29th, 1912; 3,600,000 on May 4th, 1914. The maximum is towards the end of April or beginning of May, when *Lauderia* helps, along with *Chætoceras*, to form the main crest on the vernal Diatom curve (see fig. 5).

Fig. 7.—Photo-micrograph showing a chain of *Lauderia borealis*.

Thalassiosira.

The only species of this genus that are of any importance in our records are *T. gravida*, Cleve, and *T. Nordenskioldi*, Cleve (fig. 8). Apparently *T. gravida* is the only one common at Plymouth, but *T. Nordenskioldi*, along with *Chætoceras contortum* and *C. debile*, helped to constitute the vernal maximum at Port Erin in 1907, and has been still more abundant on several occasions since. *T. Nordenskioldi* is in the main a neritic, arctic or Scandinavian species, and probably its occasional occurrences in quantity are to be regarded as invasions of some arctic water and northern plankton into our British seas. In April 1917, it was abundant at Port Erin along with *Chætoceras teres*, *C. debile*, and *C. decipiens*.

All our high records (over a million per haul) for *Thalassiosira* lie between late in April and late in May, and the two highest are six millions on April 29th, 1912, and six and a half millions on May 16th, 1913. Other high

* The largest hauls of Diatoms as a whole, all species taken together, were in May of 1912 and 1913 (see Table on p. 188).

records have occurred during these same months, in 1910, 1911, 1912, 1913, 1914, 1915, and 1916.

The highest monthly averages for *Thalassiosira* are 721,000 in April 1912, 898,000 in May 1913, and 976,000 in May 1915. The genus is totally absent from our records throughout the ten years in December,

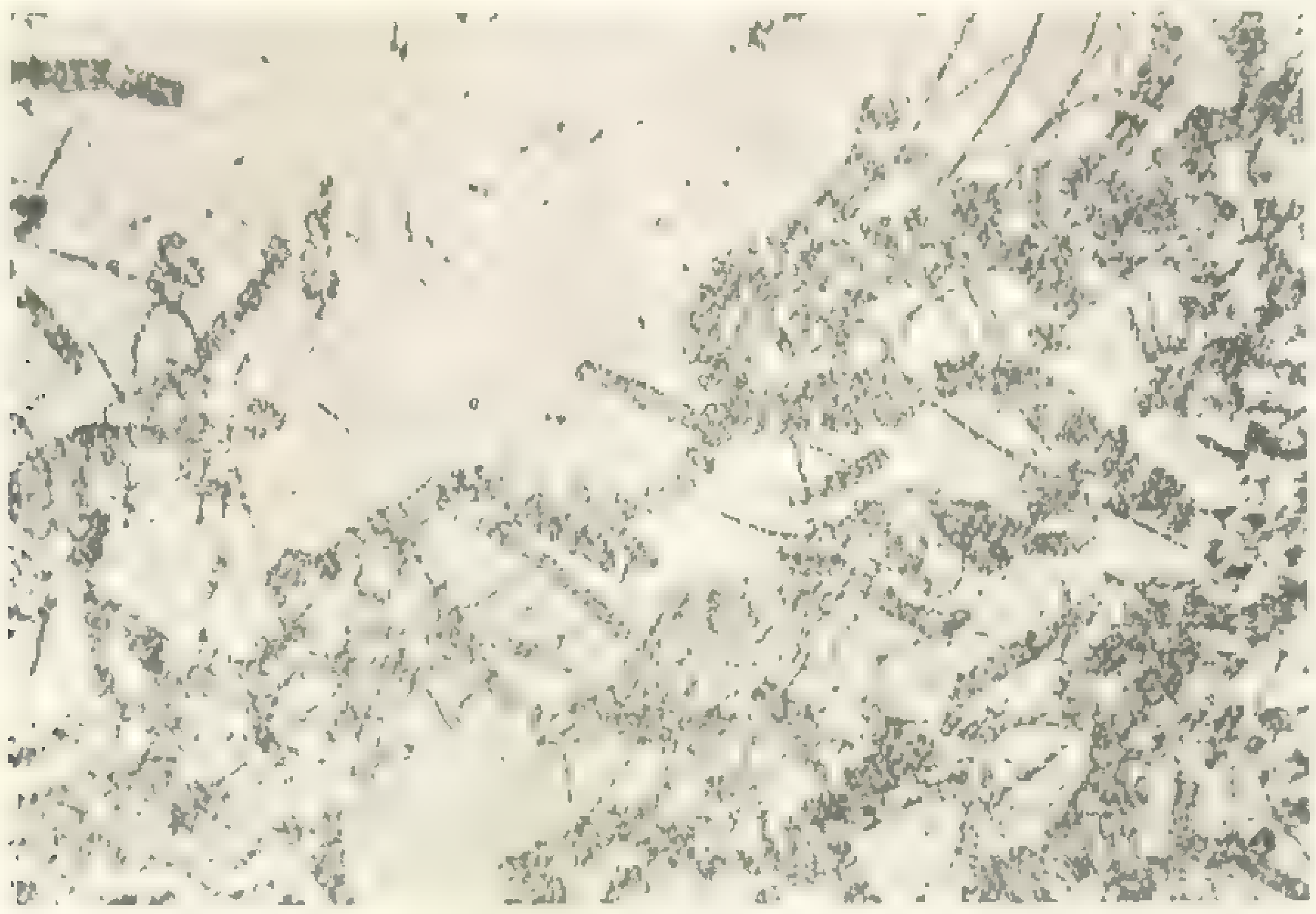


FIG. 8.—Photo-micrograph of a phytoplankton consisting mainly of *Thalassiosira Nordenskioldi*.

January, and February, and again in July and August, and is very poorly represented in several other months. In fact, it is only really abundant in April and May and not always then. In this distribution over the months of the decade this genus forms a marked contrast with *Chætoceras*, which is so constantly present.

RHIZOSOLENIA.

The species that occur most abundantly in our records are *Rhizosolenia semispina*, *R. Shrubsolei*, *R. Stolterfothi* and, less abundantly, *R. setigera* and *R. alata* (rarely). The two last named are temperate Atlantic forms, and *R. semispina* is a typically arctic oceanic species.

They are all summer or autumn species, the genus being often quite unrepresented in certain of the winter months. It usually begins to appear in the nets in February and reaches its maximum in June. The numbers are sometimes enormous, giving the water in a glass jar a characteristic silky or fibrous appearance and causing the June crest that is usually present as a distinct elevation on the Diatom curve (see fig. 5, p. 182).

The most abundant species in the Irish Sea is *Rhizosolenia Shrubsolei*—at Plymouth it is *R. Stolterfothi* ; but *R. semispina* (fig. 9) is sometimes present in abundance at Port Erin in autumn, causing a second crest or maximum in September or October. In September 1907, thirteen millions and sixteen millions of this species were taken in two hauls of the surface-net at Station III. (three miles off Port Erin), while the following year, at the same time and locality, it was almost absent.

We have had much larger numbers, of *R. Shrubsolei*, in June; and amongst our largest records of the genus taken as a whole are:—184 millions on May 30th, 173 millions on June 3rd, 59 millions on June 8th, 43 millions on June 13th, all in 1912, and 17 millions on June 21st, 1915.

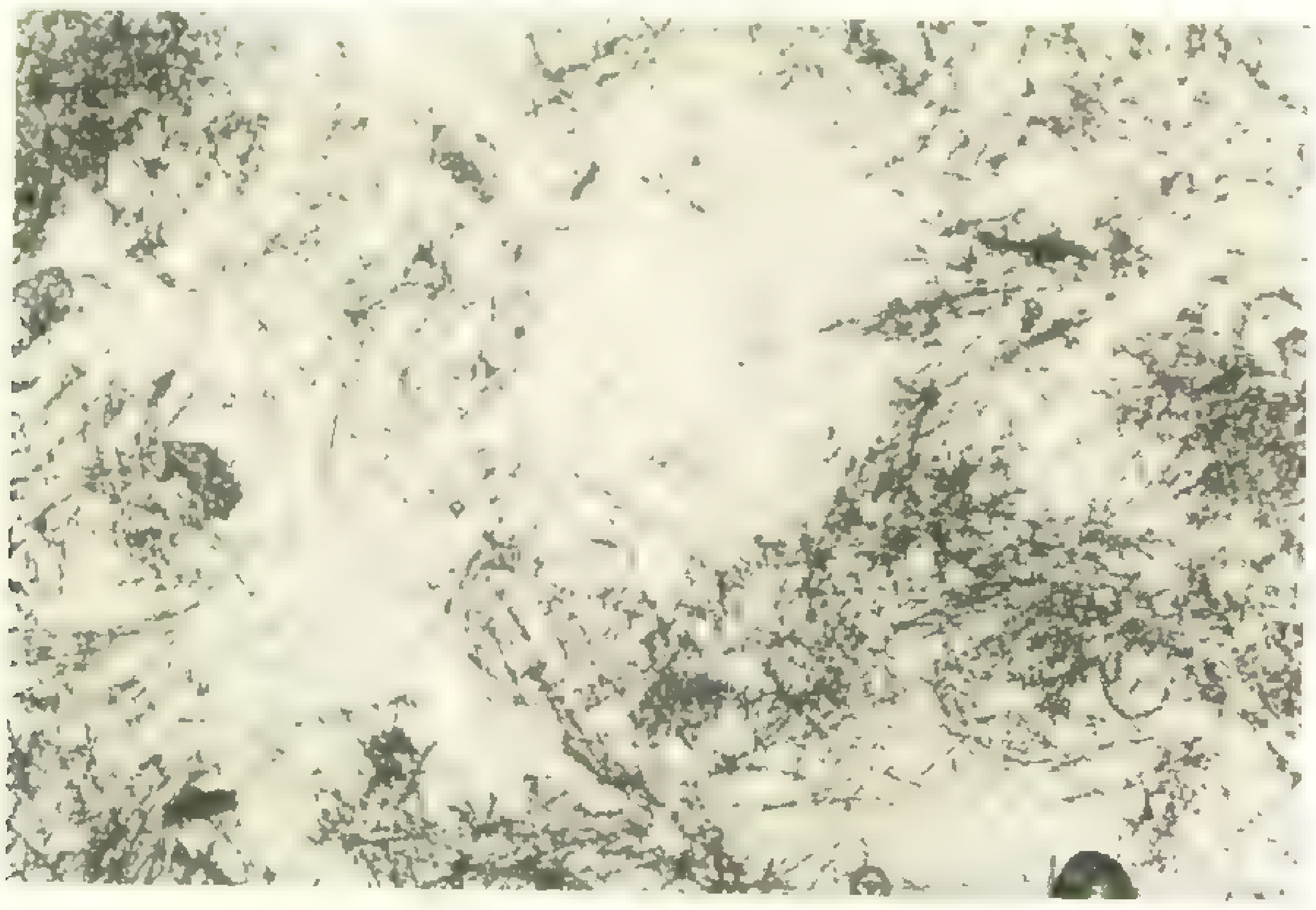


FIG. 9.—Photo-micrograph of a phytoplankton consisting mainly of *Rhizosolenia semispina.*

The highest monthly average is in June in all of our years except 1907 when it was in May, and 1913 and 1916 when it was in July. The greatest average recorded is over 40 millions in June 1912.

The autumn records are very irregular and sometimes show no rise whatever. Even when present it is slight compared with the June maximum (see fig. 5, p. 182). The highest monthly average in autumn is 117,122, in September 1912.

GUINARDIA.

Only the one species, *Guinardia flaccida*, occurs in our records (fig. 10). It is a summer form occurring mainly between April and July, with the maximum almost invariably in June. Our largest records are 22,800,000 on June 3rd, 1912; 18,000,000 on May 30th, 1912; and 8,773,000 on June 11th, 1910. We have several records of over 7,000,000 early in June, one of over two millions on July 8th, 1913, and one of over a million as late as July 16th, 1916.

Guinardia, when present, makes up along with *Rhizosolenia* the June elevation, which is sometimes so marked towards the end of the vernal Diatom maximum. This last summer (1917) it was unusually late, showing a maximum of five millions on 23rd July, along with one million of *Rhizosolenia.*

The highest monthly averages are all in June with the exception of 1916, when it was in July. The greatest recorded average is close on six millions for June 1912. The lesser, secondary, increase in autumn has its highest

point in September—the greatest recorded monthly average being 10,967 for September 1912. It is interesting to notice that according to Pavillard *Guinardia flaccida* is abundant in the Gulf of Lyons as late as October.

FIG. 10.—*Guinardia flaccida*, from a photo-micrograph by A. Scott.

TABLE

showing the monthly averages of the selected Diatoms throughout a year.

1912.	*Biddulphia.*	*Chætoceras.*	*Coscinodiscus.*	*Rhizosolenia.*	*Thalassiosira.*	*Guinardia.*	*Lauderia.*
Jan.	24,920	7,342	9,877	22	0	257	189
Feb. ..	36,885	10,301	10,034	12	0	105	0
Mar. ..	21,176	3,977,292	95,446	525	25	162	337
Apr. ..	21,869	18,365,750	100,619	36,464	721,338	3,158	1,622,478
May ..	1,072	2,844,861	14,586	22,008,744	41,033	2,789,433	170,878
June ..	0	67,543	0	40,833,771	0	5,919,429	0
July ..	0	39,527	56	1,228	0	158	0
Aug. ..	11	694,961	0	13	0	0	0
Sept. ..	4,131	7,702,658	1,677	117,122	3,978	10,967	8,944
Oct.	5,827	214,421	11,914	820	57	2,176	29
Nov. ..	25,714	9,476	5,436	0	0	21	0
Dec. ..	8,059	1,106	1,573	0	0	141	0

The above table shows very clearly how these important genera reach their maxima at different times, and how, for example, *Chætoceras* in spring (April) gives place to *Rhizosolenia* and *Guinardia* in early summer (May and June). Curves can be drawn mentally from a glance at the columns of figures which will demonstrate the waxing and waning of the several types.

The following table showing the largest hauls of total Diatoms and of total Copepoda in each of the ten years brings out well how greatly the Diatoms outnumber the Copepoda—in some cases in the proportion of about a thousand to one.

	Diatoms.		Copepoda.	
	Largest haul.	Date.	Largest haul.	Date.
1907	698,350	April 6th	28,900	Aug. 17th
1908	5,746,300	May 28th	68,015	Sept. 14th
1909	10,358,300	April 22nd	71,010	Oct. 18th
1910	70,128,400	April 22nd	119,650	Sept. 19th
1911	69,982,500	May 16th	248,045	July 18th
1912	202,993,600	May 30th	223,789*	May 20th
1913	205,814,700	May 16th	118,660	July 21st
1914	155,288,000	May 4th	217,571	Nov. 9th
1915	18,893,300	June 15th	117,340	Aug. 2nd
1916	24,260,800	May 25th	118,524	Sept. 25th
1917	64,339,250	May 3rd	147,706	July 19th

The relatively high records for Diatoms in 1912 and 1913 are due in the former case to the usual June maximum of *Rhizosolenia* and *Guinardia*, and in the latter case to a quite exceptional invasion of *Asterionella japonica*—the only occasion in our records when this genus has been abundant in the Irish Sea. We regard it as quite a rare form here. It is exceedingly abundant to the south of Iceland (Ove Paulsen) and also in the Gulf of Lyons (Pavillard).

COPEPODA.

The following table shows the total numbers recorded of our six important species of Copepoda in the years 1909 and 1910 :—

	1910.	1909.
Oithona helgolandica ...	872,678	465,066
Pseudocalanus elongatus	368,326	309,973
Acartia clausi ...	340,631	63,373
Paracalanus parvus ...	217,633	54,120
Temora longicornis ...	147,043	62,659
Calanus finmarchicus ...	15,418	21,412

* An exceptionally large haul at such an early date—due apparently to several moderately large swarms of different Copepoda occurring together, viz., *Calanus*, *Pseudocalanus*, *Temora*, and *Acartia*.

The actual detailed numbers are of no importance except as indications of the relative abundance of the species. It is clear that *Oithona* and *Pseudocalanus* (in 1909) far outnumber the others. *Acartia* shows a notable increase in 1910.

The Copepoda as a whole are a summer and autumn group, all the crests of their annual curves being found between May and October. Figure 11 shows curves of occurrence of the five most abundant of the above-named

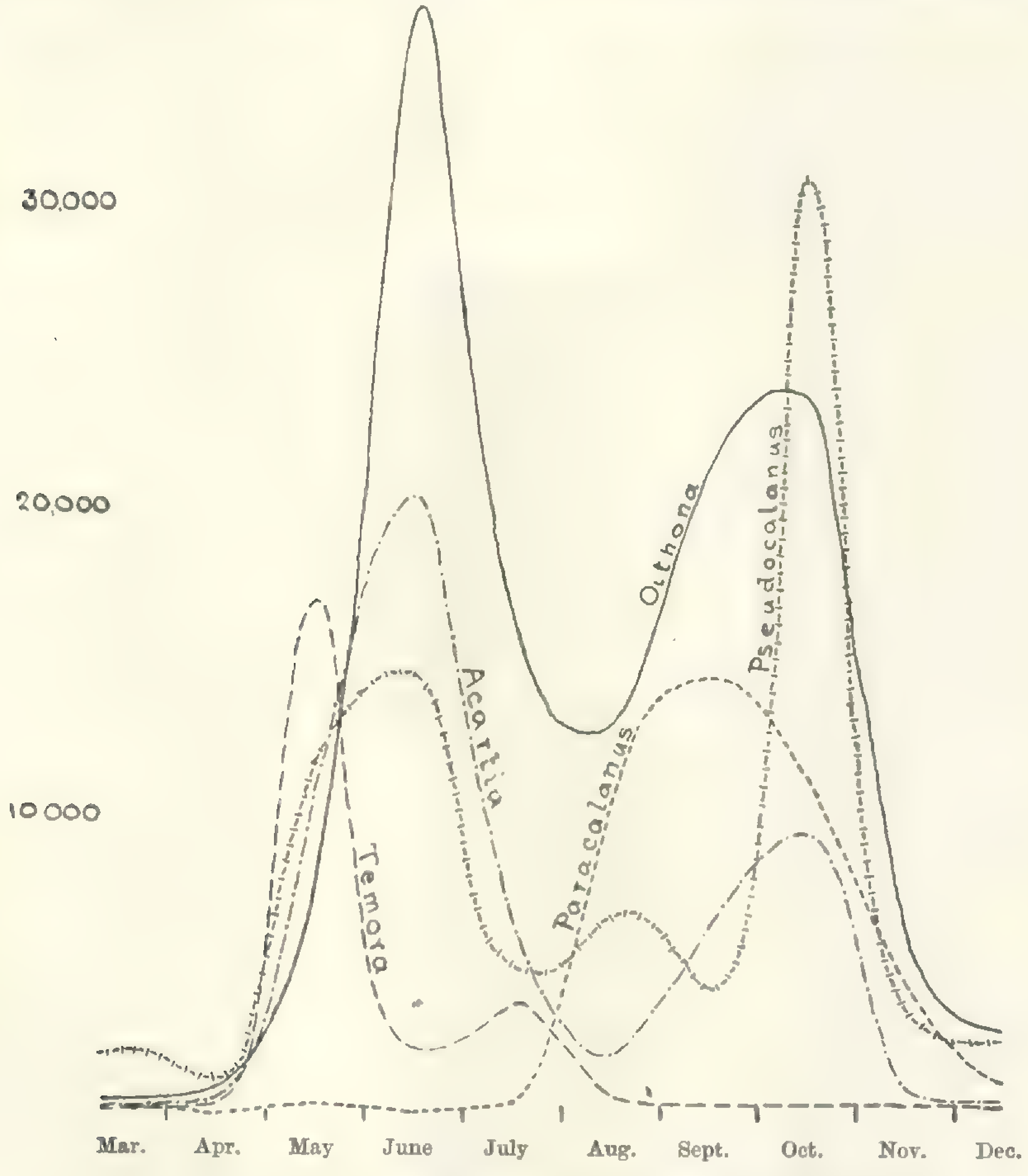


FIG. 11.—Curves of five most abundant Copepoda at Port Erin in 1912.

species for the year 1912, which may be regarded as typical. Curves of *Calanus* are shown separately in figure 12. The remaining one of our six selected species, *Calanus finmarchicus*, although much the largest individually and probably one of the most important from the fisheries point of view, only occasionally occurs in very large quantities in the Irish Sea, and its total numbers in a year are much below those of the other species, as the following table shows.

TABLE *showing the total numbers of the selected Copepoda recorded in the ten years.*

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	Totals and averages over the 10 years.
No. of hauls	77	93	112	102	107	98	95	97	101	96	978
Oithona	269,775	281,634	465,066	872,678	1,155,108	1,055,213	997,565	1,189,945	865,239	839,154	7,991,377
Average per haul ..	3,503	3,028	4,152	8,556	10,795	10,767	10,501	12,267	8,567	8,741	8.171
Pseudocalanus	113,337	177,592	309,973	386,326	365,983	643,466	500,650	487,383	788,174	679,259	4,452,143
Average per haul ..	1,472	1,909	2,768	3,788	3,420	6,566	5,270	5,025	7,864	7,076	4,583
Acartia	52,211	113,923	63 373	340,631	323,633	450,778	401,305	236,985	309,110	222,729	2,514,678
Average per haul ..	678	1,225	566	3,340	3,025	4,600	4,224	2,443	3,060	2,320	2,571
Paracalanus	25,787	91,147	54,120	217,633	351,088	363,881	196,364	568,699	119,197	138,438	2,126,354
Average per haul ..	335	980	483	2,134	3,281	3,713	2,067	5,863	1,180	1,443	2.276
Temora	104,093	20,495	62.659	147,043	106,359	210,542	144,624	146,707	118,218	146,174	1,206,914
Average per haul ..	1,350	220	559	1,442	994	2,148	1,522	1,512	1,170	1,523	1,234
Calanus	21,352	19,646	21,412	15,481	5,843	79,429	23,183	42,494	13,119	18,031	259,990
Average per haul ..	277	211	191	152	55	810	244	438	130	188	266

Calanus.

Calanus finmarchicus (Gunner) * is present throughout the year in the Irish Sea, and may be taken in small quantities at almost any time and in larger numbers on different occasions in different years. In 1907 it was fairly abundant (a few thousands in a haul) in April, and again at the end of July and the beginning of August, and in October. In 1908, on the other hand, the thousands per haul were not reached until later in the year, and the numbers remained relatively high from September to December (2,850 on December 23rd). In 1909, in addition to occasional thousands in May,

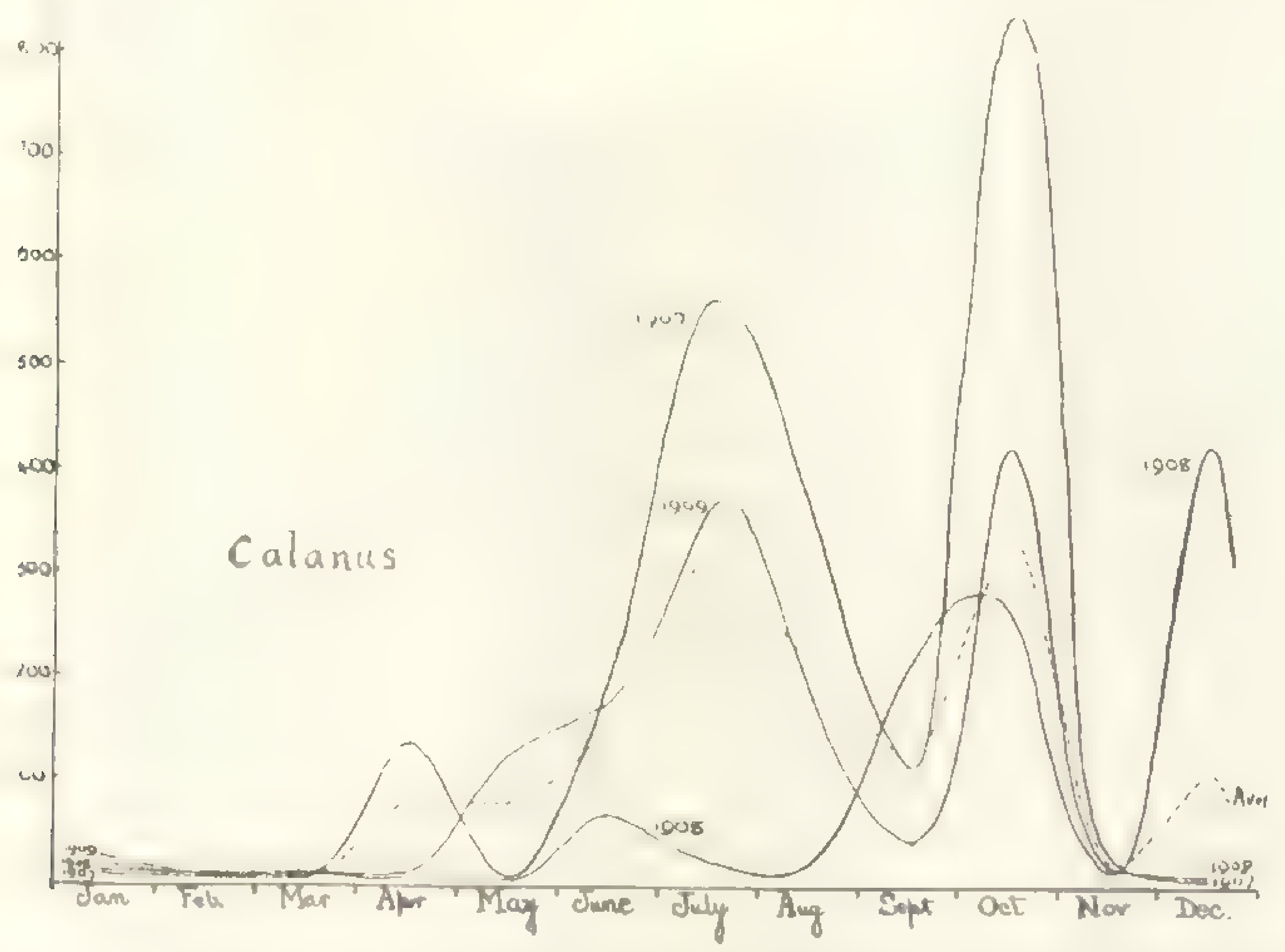


Fig. 12.—Curves of *Calanus* for three years (1907–9) at Port Erin, showing successive waves of invasion, 2 or 3 in each summer.

June, July, and October, we have evidence of an unusually large swarm that entered the bay on July 17th and 19th, when hauls estimated at 20,000 each were obtained. The average for these three years shows maxima in July and October (see fig. 12).

In 1910 there were no very large hauls, and the thousands were only reached at the end of July and the beginning of August—perhaps the most usual time for swarms to appear in the bay.

In 1911 the numbers in general were low, but two of the customary large swarms appeared in summer, one on July 4th and the other on July 18th.

In 1912 the numbers were higher again, and thousands occurred on various dates from April to October. The very high record of 50,720 was obtained on May 17th, unusually early for such a large swarm.

* I use this older specific name as I am inclined to agree with Wolfenden, Esterly and others that the characters used in the attempt to separate "finmarchicus" and "helgolandicus" as species are too slight and inconstant to be relied upon.

In 1913 the numbers were lower, and the maximum was 4000 on July 28th.

In 1914 the maximum was 7320 on August 6th.

In 1915 again the numbers were low, the highest being 3232 on July 1st.

In 1916 a swarm appeared in the bay on July 11th, when over 12,000 were taken in a haul. A few days before a similar haul gave only 10 specimens, and a few days after 200. The average per haul at Port Erin over the ten years is only 266.

On the whole this record agrees well with that at Plymouth, which is "Common on and off from the end of April to the beginning of November, generally present in small numbers at other times" (Miss Lebour).

FIG. 13.—*Calanus finmarchicus*, from a photo-micrograph by A. Scott.

Calanus finmarchicus (fig. 13), as its specific name suggests, is a northern or Scandinavian form with a wide distribution through the colder waters of the North Atlantic. According to Ove Paulsen its home and centre of distribution lies to the south of Iceland.

In Loch Fyne on the west coast of Scotland, off Skate Island, *Calanus* appears to be present throughout the year in great quantities, in deep water, at or near the bottom, along with *Euchæta norvegica* and *Nyctiphanes norvegica*. For example, in July 1907, off Skate Island in 104 fathoms, we caught 13,000 *Calanus* in one vertical haul, and on another occasion off East Loch Tarbert, in 76 fathoms, we got 10,000. We have also obtained

from the yacht at various localities in the deep lochs on the west coast of Scotland large hauls of *Calanus* by means of vertical hauls when no specimens were obtained at the surface. In fact this Copepod seems to be permanently present in the deeper waters of these lochs.

In addition to these deep water specimens of *Calanus* we find on occasions, on the west coast of Scotland, large swarms on the surface, which may be the result of invasions from the ocean, and there is a considerable amount of evidence that such swarms are the cause of local mackerel fisheries.

Some years ago (1909) Dr. E. J. Allen and Mr. G. E. Bullen published * some interesting work, from the Plymouth Marine Laboratory, demonstrating the connection between mackerel and *Calanus* and sunshine in the English Channel; and Farran † states that in the spring fishery on the West of Ireland the food of the mackerel is mainly composed of *Calanus*. In the summer of 1913 we had an experience at Tobermory, in Mull, which I shall quote from two letters written from the yacht at the time, and published in 'Nature.'

"S.Y. 'Runa,' Tobermory, July 12th, 1913.

"On arriving in this bay last night we found that the local boats had been catching abundance of mackerel close to. We bought some for supper (good fish for a halfpenny each), and on dissection found that the stomachs of all of them were crammed full of fresh-looking *Calanus* (the individual Copepods being for the most part distinct and perfect), along with a few immature *Nyctiphanes* and larval Decapods. Professor Newstead and my daughter then noticed, while fishing over the side of the yacht, about 8 p.m., that the gulls in the bay were feeding in groups around patches of agitated water evidently caused by shoals of fish. On rowing out to these we saw distinctly the mackerel, large and small, darting about in great numbers in the clear water, and we also noticed every here and there on the smooth surface of the water—it was a beautifully calm evening—innumerable small whirls or circular marks which, looking closely, I found to be caused by large Copepoda close to the surface.

"About twenty years ago I sent a note to 'Nature,' from the yacht 'Argo,' in regard to large Copepoda (I think it was *Anomalocera* on that occasion, and the locality was further north, off Skye), splashing on the surface so as to give the appearance of fine rain; and this present occurrence at once reminded me of the former occasion, but here the Copepod was *Calanus finmarchicus* of large size and in extraordinary abundance. They could be clearly seen with the eye on leaning over the side of the boat, a small glass collecting jar dipped at random into the water brought out twenty to thirty specimens at each dip, and a coarse grit-gauze tow-net of about 30 cm. in diameter caught about 20 cubic centimetres of the Copepoda in five minutes.

* Journ. Mar. Biol. Assoc. vol. viii. (1909) pp. 394–406.

† Conseil Internat. Bull. Trimestr. 1902–8, Planktonique, p. 89.

The mackerel were obviously darting about, occasionally leaping to the surface (which gave the gulls their opportunity) where the whirls, caused by the Copepoda, were thickest, and an examination of the stomach-contents of the fish on the yacht afterwards, showed us that the amount in one mackerel was about the same quantity as that caught by the tow-net in five minutes. Professor Newstead and I have made a count of 8 c.c. of the tow-net gathering, and estimate that it contains about 2400 specimens of *Calanus.* This would give about 6000 Copepods in the stomach of an average mackerel, or in a five-minutes' haul of the tow-net, on this occasion.

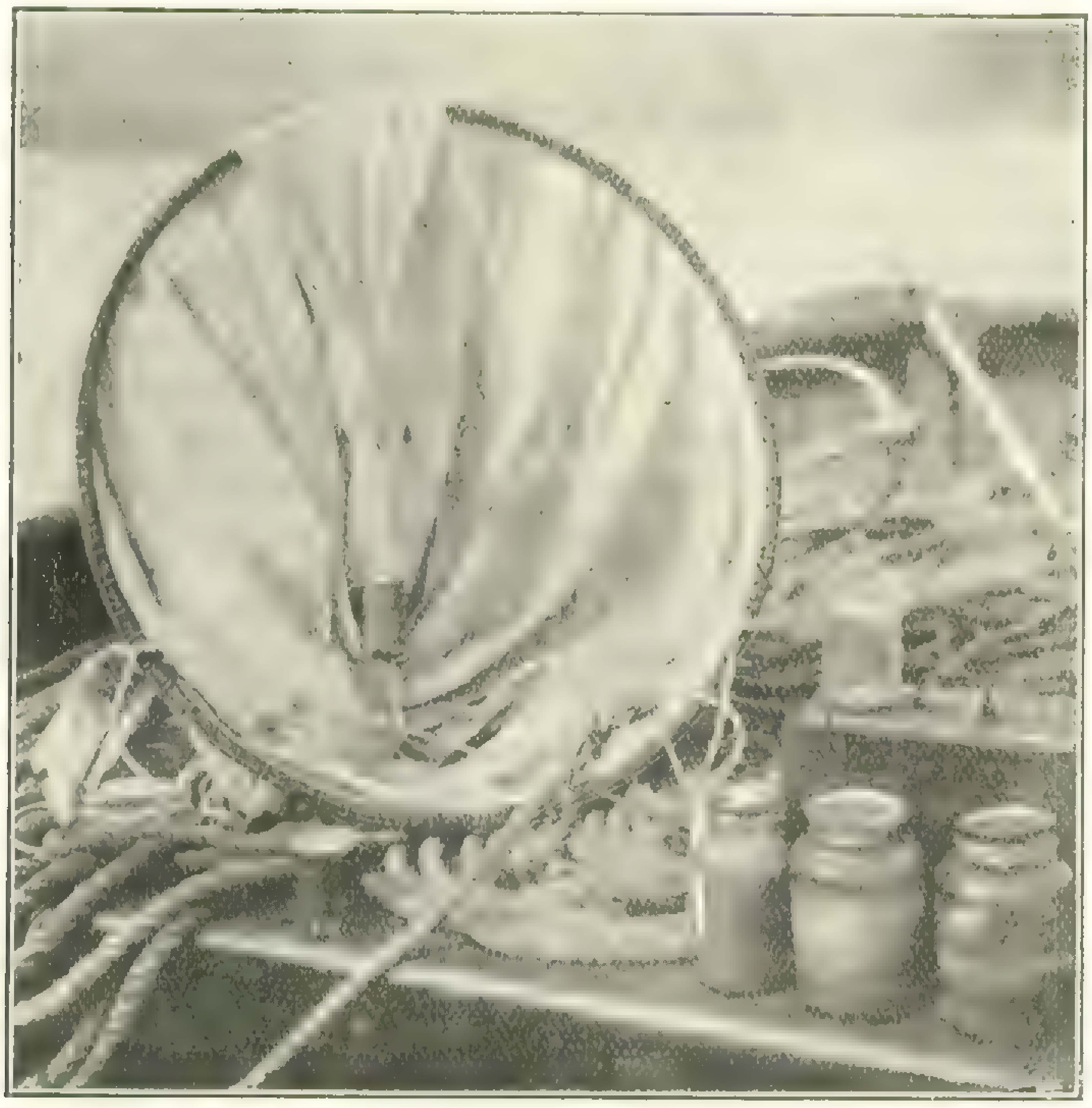


FIG. 14.—Photograph of exceptionally large hauls (about 1000 c.c. in a jar) of *Calanus* taken from the yacht 'Runa' in 1913 on the west coast of Scotland. The largest haul was estimated to contain at least half a million individuals.

"It may be added that these mackerel were evidently not being nourished in accordance with the views of Pütter, and were clearly able to fill their stomachs from the plankton around them.". . . .

The following note, written some weeks later, records the conclusion of the matter, so far as that summer's observations went :—

"S.Y. 'Runa,' off Island of Eigg, August 12th, 1913.

"On getting back to Tobermory on Saturday, we found the plankton to be in marked contrast to its condition four weeks ago. The vast swarm of

Calanids has gone, and there are now no signs of mackerel feeding in the bay. In fact, the change has been noticeable for some days in the seas outside, and we have not been getting lately the large plankton catches that were usual in the latter half of July. On July 14th a haul of the large surface tow-net, in the open sea off Ardnamurchan, gave such a huge catch of *Calanus* (about 1000 c.c.) that we promptly took a second similar haul, and had it cooked as a sort of potted 'shrimp' confection for tea (sampled by ten persons, including the crew, who were much interested to try this new edible 'fish'); while on August 11th a haul of the same net, taken at the same spot, gave only a small catch of some 15 c.c., containing very few Calanids, along with the usual scanty summer zooplankton." . . . .

The importance of *Calanus* as a food for migratory pelagic fishes such as the mackerel cannot be doubted (see fig. 14).

PSEUDOCALANUS.

Pseudocalanus elongatus (Boeck) is widely distributed in the North Atlantic and is present in the Irish Sea throughout the year (fig. 15). It reaches its lowest level in January and February, and has its maximum in late summer and autumn (June to October in our records, generally September or October).

FIG. 15.—*Pseudocalanus elongatus*, from a photo-micrograph by A. Scott.

This Copepod comes next after *Oithona* as the second most abundant species in the Irish Sea, its average per haul over the ten years being 4583.

Some of the most important records are :—65,200 on May 20th, 1912; 91,960 on October 21st, 1912; 68,120 on June 24th, 1913; 60,600 on May 5th, 1916; 59,600 on September 25th, 1916; 58,200 on October 31st, 1912; 54,350 on July 31st, 1911; and many other records between 35,000 and 50,000 in these same months.

Paracalanus.

Paracalanus parvus (Claus) is a southern form (fig. 16) which extends to the tropics and has a wide distribution. It is present in quantity only during autumn and winter in the Irish Sea, being practically absent between February and July, and having its maximum in September or October. The largest hauls are in autumn, for example, 59,460 on September 7th ; 138,300 on September 10th ; 53,500 on September 15th, all in 1914 ; 61,930 on August 24th, 1911 ; 49,800 on September 8th, 1910 ; 49,390 on September 7th, 1912 ; 44,060 on October 24th, 1912 ; while other large hauls in the same months range from 25,000 to 40,000.

Fig. 16.—*Paracalanus parvus*, from a photo-micrograph by A. Scott.

This is a species that has varied considerably in quantity from year to year, its average per haul ranging from 335 in 1907 to 5863 in 1914. In the present year, 1917, it was especially abundant at Port Erin in September, along with *Oithona*.

Oithona.

Oithona helgolandica (= *O. similis*), Claus, is the most generally abundant Copepod throughout the year in the Irish Sea ; but the months when it is taken in greatest numbers are June to November (inclusive) with the maximum generally in July. There may, however, be a second maximum later, in October or November.

The following may be quoted as exceptionally large hauls :—The highest, 225,450, is on July 18th, 1911, and the next highest, 199,300, is on November 9th, 1914 ; then we have 93,580 on July 28th, 1913, 87,530 on September 26th, 1912, and 83,550 on June 14th, 1910. We have twenty other records of over 44,000 each scattered over the months June to November. This is the Copepod which has the highest average number per

haul over the ten years, viz., 8171 (see table, p. 190). Although this is a small species (fig. 17), still from its very great abundance it must be of considerable economic importance as a food-matter in the sea.

FIG. 17.—*Oithona helgolandica*, from a photo-micrograph by A. Scott.

ACARTIA.

Acartia clausi, Giesbr., is a summer species widely distributed over the North Atlantic, and present in greatest abundance in the Irish Sea from May to October (inclusive), and having a maximum generally in June, with another slighter rise in autumn, September or October.

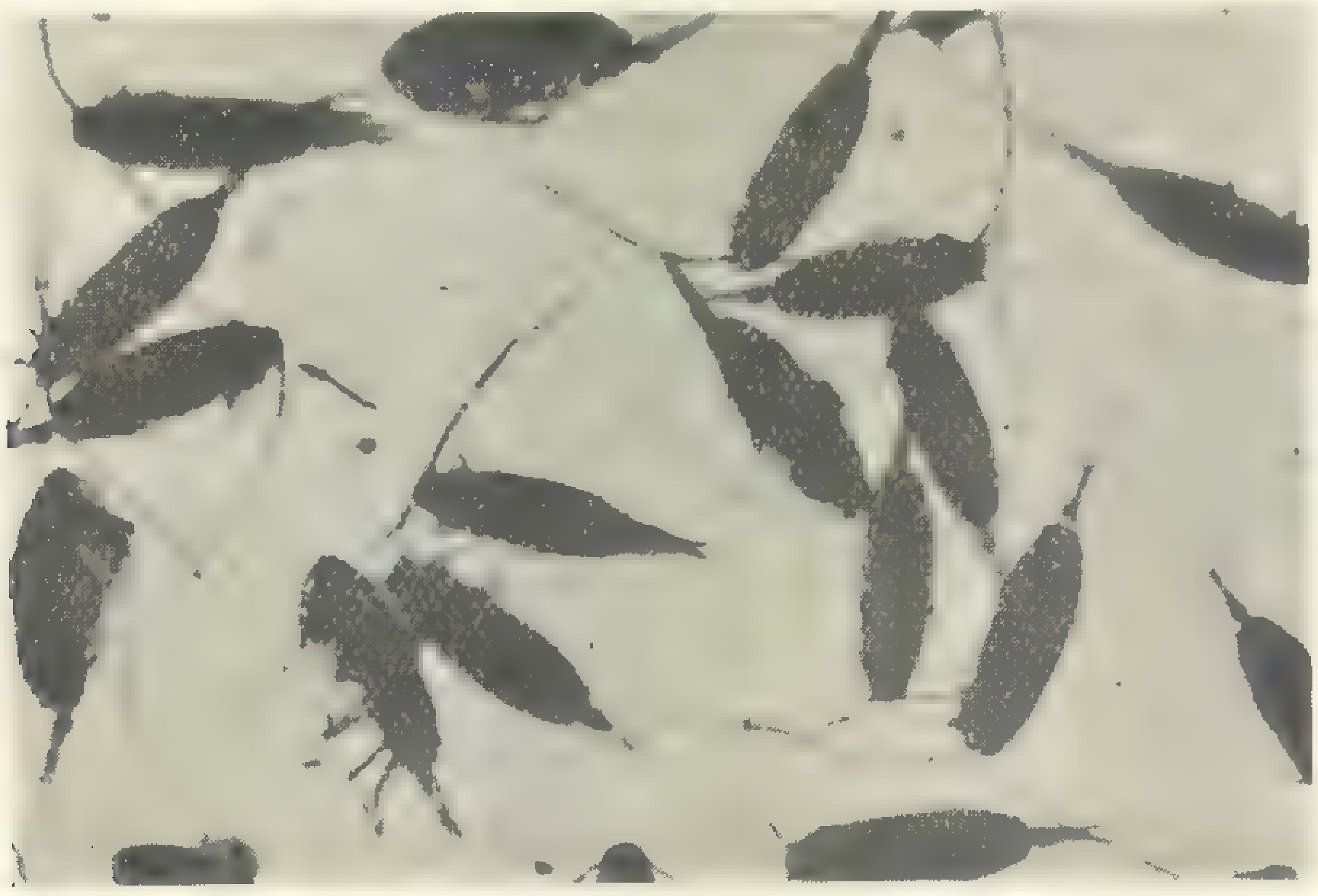


FIG. 18.—*Acartia clausi*, from a photo-micrograph by A. Scott.

The following are some of our highest records :—59,490 on June 27th, 1912 ; 59,360 on August 24th, 1911 ; 52,200 on May 20th, 1912 ; 50,100 on June 2nd, 1913 ; 44,000 on September 29th, 1913 ; and 41,950 on June 17th, 1912. The average of this species per haul throughout the ten years

is 2571. Swarms of this oceanic species (fig. 18) in summer may possibly be connected with an inflow of Atlantic water ; but probably also large numbers appearing locally in enclosed areas may be the result of reproduction and development *in situ*.

In some cases *Acartia* has been found in unusual abundance quite close to the shore, and even in water of low salinity.

Towards the end of September, 1917, we emptied for cleaning purposes the large open-air fish-ponds at the Port Erin Biological Station, and when most of the water had been pumped out we noticed that what remained was swarming with small Copepoda. Every bucket and jarful that one removed for inspection was found to be densely crowded—as densely, in fact, as an average jar of plankton representing the contents of a standard haul. Some buckets of these Copepoda were used for feeding the lobster larvæ and some of the smaller fish and other animals in the Aquarium, and a small sample that was preserved was found to be a practically pure gathering of *Acartia clausi*. One specimen of *Centropages* was present in the tube amongst many thousands of *Acartia*, when Mr. Scott took the photo-micrograph shown in fig. 18.

TEMORA.

Temora longicornis (Müll.) is a very local species, which may be found on occasions swarming in great abundance in small areas of the sea, generally close to land. It is a summer species and its maximum is generally in June

FIG. 19.—*Temora longicornis* from the stomach of a Mackerel. From a photo-micrograph by A. Scott.

or July, but was in May in 1912, when the large hauls of 50,400 and 83,400 were taken on the 17th and 20th respectively. Other large hauls of this

species in our records are :—45,530 on July 11th, 1916 ; 43,800 on June 11th, 1913 ; and 34,665 on July 26th, 1910. The average for this species per haul throughout the ten years is 1234.

Temora (fig. 19) is characteristic of coastal as opposed to Atlantic water, and is the only "neritic" form in our series. The other five are all usually classed as "oceanic," but as I have pointed out above most of them are really present throughout the year in the Irish Sea.

Temora longicornis is on occasions one of the most abundant of our Copepoda in the Irish Sea and must be of considerable importance as a food for fish and especially for the herring in summer. In the latter part of July and the first half of August, 1917, the shoals of herring to the west of the Isle of Man came unusually close to land and even penetrated into bays and creeks ; and during this time they were feeding mainly, if not wholly, on

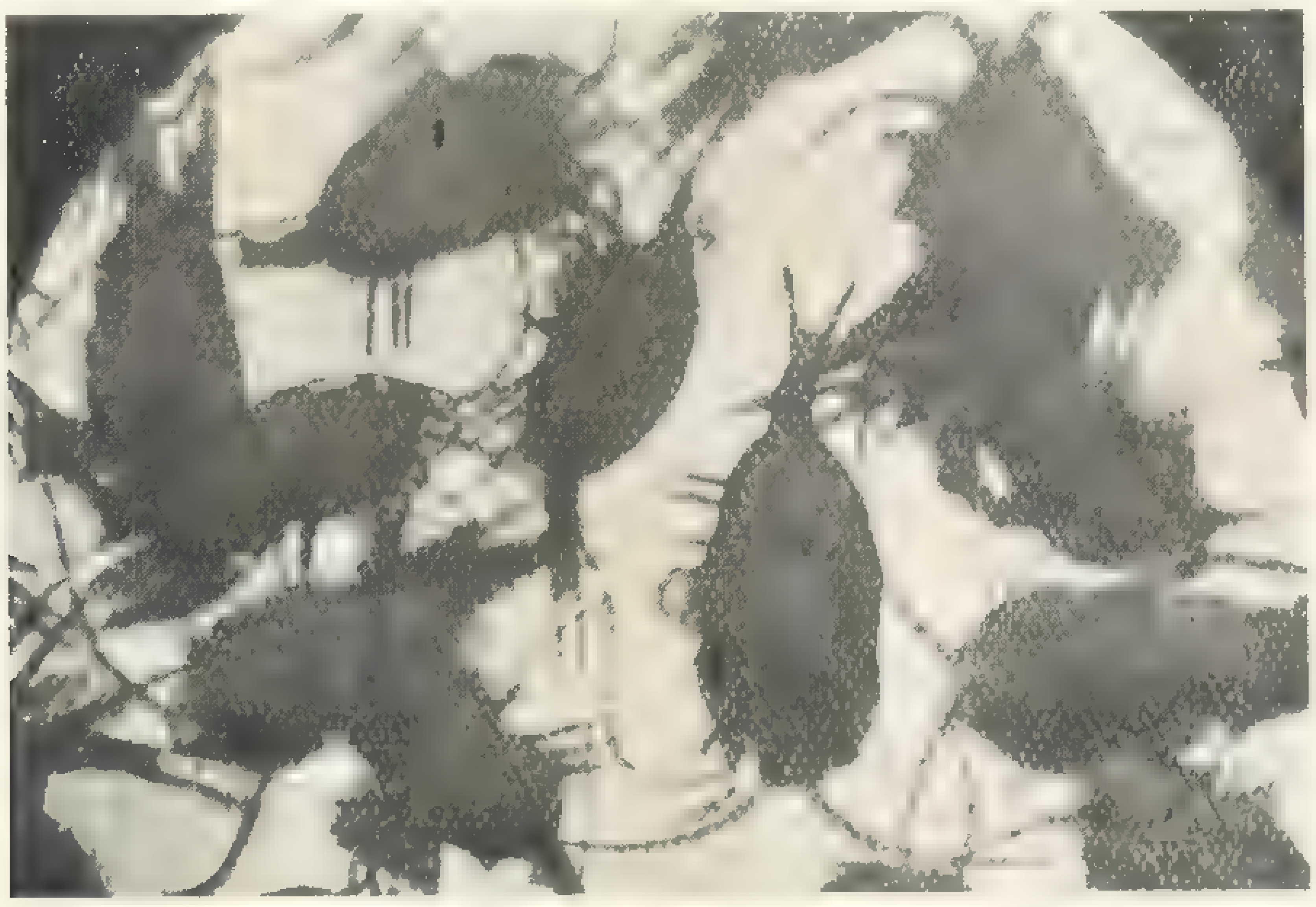


FIG. 20.—*Temora longicornis* from the "red patches." From a photo-micrograph by A. Scott.

Temora. Late in July this Copepod was so abundant that its presence caused large patches of a red colour on the surface of the sea off Port Erin and around the Calf Island. These red patches were noticed by the fishermen, and were spoken of amongst them as being "fish-food" or "spawn." A large jarful from such a red patch, obtained by one of the fishermen, was brought to the laboratory and found to be swarming with small Copepoda, which on examination proved to be almost wholly *Temora longicornis* (fig. 20). About one-fourth part of the contents of the jar was preserved, and on being counted later on was found by Mr. Andrew Scott to amount to 50 c.c. of Copepoda, consisting of 33,340 *Temora* and 2 *Calanus*. Mr. Scott estimated the oil present in 9 c.c. of the dried *Temora* at 2·47 per cent. of the weight, which was 0·925 gramme.

During this same time the men were catching herring in quantity unusually close inshore in the neighbourhood of the red patches, and on examining, in

the laboratory at the Biological Station, the stomach-contents of a number of these herrings, I found in every case that the stomach contained a mass of red material which was obviously, under the microscope, the broken-down remains of Copepoda. A few Crab zoea were recognisable, but the bulk of the material consisted undoubtedly of the Copepoda. Mr. Scott examined 5 c.c. of the stomach-contents for me, and found that it contained 975 easily recognisable specimens of *Temora*. A photograph (fig. 21), which Mr. Scott

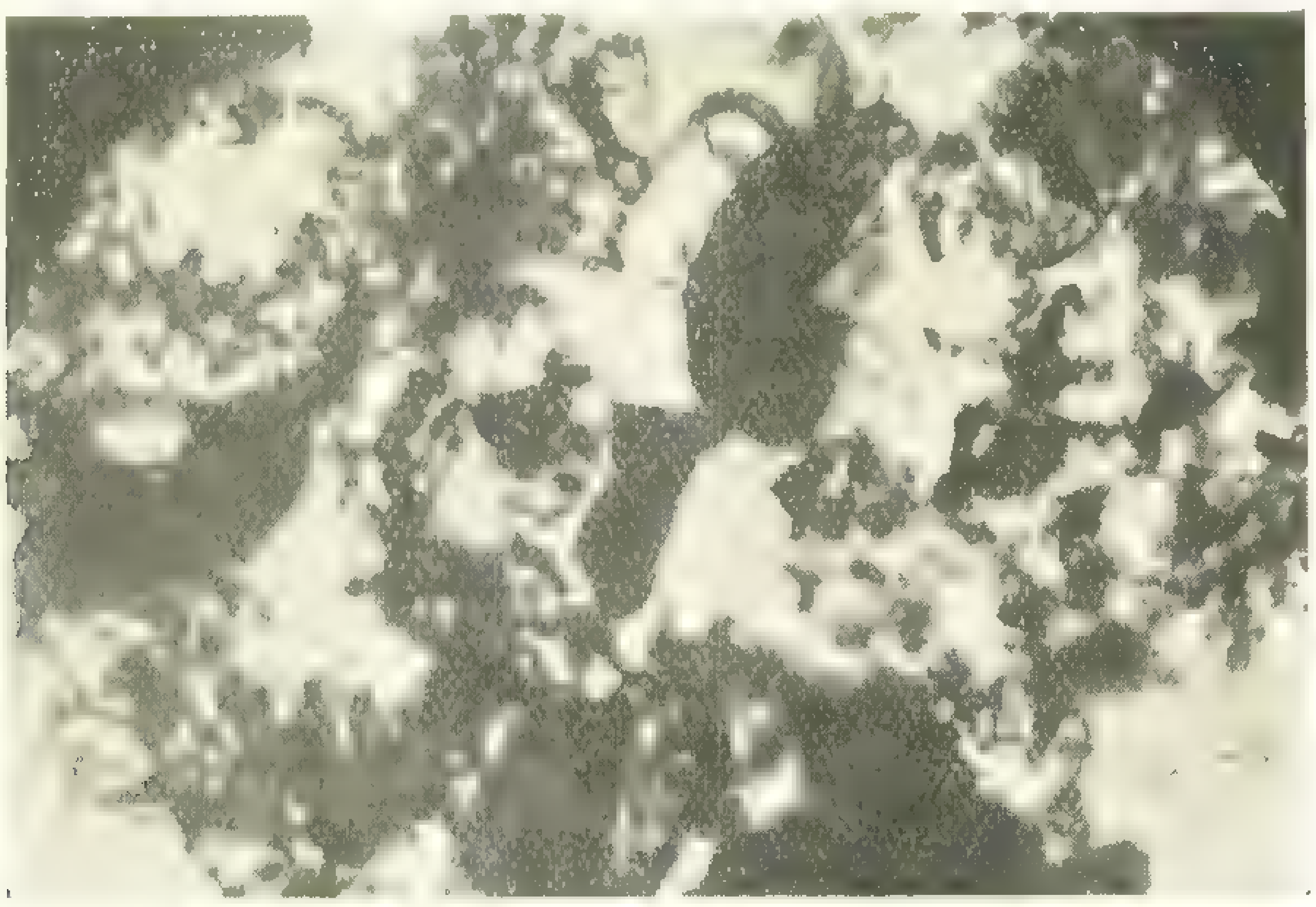


FIG. 21.—*Temora* remains from the stomachs of the Herring.
From a photo-micrograph by A. Scott.

has made from one of the microscopic preparations, shows appendages that undoubtedly belong to this Copepod, while here and there in the stomachs complete specimens of *Temora* are to be seen. It is not possible to doubt that during these weeks, at the height of the summer herring fishery in the Irish Sea, the fish were feeding mainly upon this species of Copepod.

We recorded a similar occurrence off the Lancashire coast a few years ago, when in July 1913, at the time of an abundant mackerel fishery off Walney Island, the stomachs of some of the fish were found to be full either of *Temora* alone or of *Temora* mixed with *Isias* and a few other Copepoda (see fig. 19, p. 198). A few herrings from the Port Erin fishery of July 1916 were found by Mr. Scott to be feeding mainly on *Calanus*.

CONCLUDING REMARKS.

Many food-fishes are known to feed upon Copepod plankton during at least some portion of their life. The Loch Fyne herrings are frequently at the time of a fishery found to have their stomachs filled with *Euchæta* or *Calanus*. Mackerel, in the English Channel and to the S.W. of Ireland and elsewhere, have been recorded as feeding on *Calanus*. It has been shown in this paper that in Hebridean Seas the mackerel and in the Irish Sea herrings,

at a time when they are present in great abundance, are feeding on some prevalent form of Copepod, such as *Calanus* or *Temora*. Other similar cases could no doubt be quoted and are known to marine biologists.

Then, as to demersal fish—young plaice, after their metamorphosis, feed chiefly on the smaller Copepoda, while in younger stages the post-larval plaice feeds upon Diatoms. We have noticed at the Port Erin Biological Station the post-larval plaice with its stomach showing of a golden brown colour from the Diatoms with which it was filled, and we have watched in a shallow pond the metamorphosed young plaice darting backwards and forwards pursuing, catching, and devouring the individual Copepoda. It is known that these Copepoda in their turn feed in part at any rate on Diatoms, so our two main constituents of the plankton are undoubtedly concerned in the nourishment of either young or adult fishes useful to man.

The association of shoals of fish with abundance of plankton is the result of the fact that, in order to get an adequate quantity of planktonic food, the fish must seek out and capture the Copepoda. In other words, the fish must go where the plankton is abundant and must in its movements follow the movements of the shoals of Copepoda. It is the very poverty of the plankton in some sea-areas, insisted on by Pütter, Lohmann and others, which makes it necessary for plankton-eating fish to move about in search of more abundant supplies.

Consequently it is of importance to show, as we now can, that in our coastal seas at least, where the fisheries we are interested in take place, the plankton is not uniformly distributed. Many of the Copepoda occur very definitely in local swarms, and various localities and depths are characterised at the different seasons by particular assemblages of plankton. It is therefore reasonable to believe, in view of the facts given above as to the association of fish and plankton, that these variations in the distribution must have a marked effect upon the presence and abundance of at least such migratory fish as herring and mackerel, and also of the shoals of post-larval young of many of our other food-fishes.

No less than three masses of sea-water of different origin and character may enter or affect the British seas in varying quantity, viz.:—(1) Arctic water such as normally surrounds Iceland and the east of Greenland, and may extend further southwards and eastwards towards Norway, the Faroes, and Shetlands; (2) Atlantic ("Gulf-stream Drift") water which impinges on the western shores of Ireland, and may flood the English Channel and extend round the Shetlands or down into the North Sea; and (3) "Coastal" water such as flows out from the Baltic and, mixed with the other waters, bathes the coasts of N.W. Europe generally, and to a large extent surrounds the British Islands.

The Irish Sea may be regarded as primarily an area of coastal water, which is, however, liable to be periodically invaded to a greater or less extent

by bodies of warmer and salter Atlantic water (re-inforced possibly by portions of a deeper outflowing Mediterranean current) carrying in oceanic plankton, and more rarely perhaps by Norwegian or Arctic water causing an invasion of northern organisms. The variations which we find in different years in the nature and amount of the plankton at the same localities no doubt depend to some extent upon the volume and period of such southern or northern invasions; but they may depend also upon other factors, such as the weather (temperature, sunshine, rainfall, wind, etc.) at the time, and previously.

Of the six Copepoda discussed above only one—*Temora*—is a neritic form; the others are all usually regarded as oceanic, that is as having their true home and centre of distribution somewhere to the north, west, or south in the open Atlantic.

The following list gives an approximate indication of what is supposed to be the source of these five oceanic Copepoda:—

Calanus.—N. Atlantic, about Iceland ("Boreal oceanic").

Paracalanus.—Southern, temperate and tropical Atlantic.

Pseudocalanus.—N. Atlantic ("Boreal oceanic").

Oithona.—N. Atlantic ("Boreal oceanic").

Acartia.—N. Atlantic ("Northern styli-plankton").

Some no doubt live on during the year in the Irish Sea, but these indigenous populations are probably reinforced by waves of immigration from outside.

In the case of our Diatoms some of the species of a genus may be neritic and others oceanic, as is shown in the following list, where (N.) stands for neritic and (O.) for oceanic, and a (?) indicates that the evidence seems to me conflicting or inconclusive *:—

Biddulphia mobiliensis (N.), *B. sinensis* (O.).

Coscinodiscus radiatus (O. ?), *C. concinnus* (N.), *C. Grani* (N.).

Lauderia borealis (N.).

Chætoceras boreale (O.), *C. criophilum* (O.), *C. decipiens* (O ?), *C. densum* (O.), *C. contortum* (N.), *C. debile* (N.), *C. diadema* (N.), *C. sociale* (N.), *C. subtile* (N.), *C. teres* (N.).

Thalassiosira gravida (N.), *T. Nordenskioldi* (N.).

Rhizosolenia alata (O.), *R. semispina* (O.), *R. setigera* (N.), *R. Shrubsolei* (N. ?), *R. Stolterfothi* (N. ?).

Guinardia flaccida (N. ?).

It is remarkable how small a number of forms make up the bulk of the macro-plankton throughout the year. These half-dozen kinds of Diatoms and half-dozen Copepoda are the all-important organisms upon which our

* The matter was discussed more fully some years ago in a paper by Herdman and Riddell in Trans. Biol. Soc. Liverpool, xxv. (1911) p. 178.

fate depends so far as concerns food from the sea. That shoals of migratory fish such as herrings and mackerel are attracted in summer and autumn by dense swarms of certain Copepoda such as *Calanus* and *Temora* can no longer be doubted ; and there is abundance of evidence that earlier in the year the young stages of other food-fishes, such as plaice, are nourished first by Diatoms and when larger by the smaller Copepoda. These conclusions, however, do not finish the matter. There remains in the sea the much more minute Protozoa and Protophyta of the Nannoplankton, which to a large extent escape through the meshes of our plankton nets and which are doubtless of great importance as the food of Copepoda and other large organisms which in their turn nourish fish.

There are several other interesting lines of further investigation which open up as collaterals from plankton investigation. One of these is the origin of the great vernal phytoplankton maximum. In the spring there is an awakening of the plant-life of the sea comparable to the growing of the grass and the budding of the trees on land. This cannot be due to any rise in temperature, as the sea at the time that the Diatoms start their active growth and reproduction is at its coldest. We have series of observations extending over more than ten years showing that the water of Port Erin bay is generally of lower temperature in March than in December or January. Of the various causes for the rise in the Diatom curve in these cold waters of early spring I have for some years * regarded with greatest favour the view suggested first by Sir John Murray, viz., the increase in sunlight at that time of year. In that case it would be a photosynthetic phenomenon—the increased solar light energy enabling the Diatoms to obtain from their environment by photosynthesis the materials required for their growth and reproduction. The view that the spring increase in plankton is due to changes in the alkalinity of the water does not in my opinion conflict with the photosynthesis theory but is supplementary to it. The position in regard to the relation between variations in alkalinity and in the plankton, in our district, is as follows :—

The sea around the Isle of Man is a good deal more alkaline in spring (say April) than it is in summer (say July) ; and during the years 1912–14 Professor Benjamin Moore, by examining samples of sea-water periodically at the Port Erin Biological Station, was able to show † that the alkalinity, which gets low in summer, increases somewhat in autumn, and then decreases rapidly, to disappear during the winter ; and then once more, after several months of a minimum, begins to come into evidence again in March and rapidly rises to its maximum in April or May. This periodic change in alkalinity will be seen to correspond roughly with the changes in the living

* See "Intensive Study, &c." Part III. p. 260, 1910, Trans. Biol. Soc. Liverpool, xxiv.

† Trans. Biol. Soc. Liverpool, xxix. (1915) p. 233.

microscopic contents of the sea represented by the phytoplankton annual curve, and the connection between the two will be seen when we realise that the alkalinity of the sea is due to the relative absence of carbon dioxide. In early spring, then, the developing myriads of Diatoms in their metabolic processes gradually use up the store of CO_2 accumulated during the winter and so increase the alkalinity of the water, till the maximum of alkalinity, due to the reduction in amount of carbon dioxide, corresponds with the crest of the phytoplankton curve in, say, April. Prof. Moore has calculated that the annual turn-over in the form of carbon which is used up or converted from the inorganic into an organic form probably amounts to something of the order of 20,000 or 30,000 tons of carbon per cubic mile of sea-water in the Irish Sea; and this probably means a production each season of about two tons of dry organic matter, corresponding to at least ten tons of moist vegetation, per acre—which shows that we are still very far from getting from our seas anything like the amount of possible food-matters that are produced annually.

Testing the alkalinity of the sea-water may therefore be said to be merely ascertaining and measuring the results of the photosynthetic activity of the great phytoplankton rise in spring due to the daily increase of sunlight.

Other possible causes, more or less related to the above, have been suggested —such as Brandt's hypothesis that the fluctuations in the phytoplankton depend upon the accumulation, and then the exhaustion, of necessary inorganic food-matters in the water, such as nitrogen or phosphorus compounds or silica ; and the view of Nathansohn, Gran and others that vertical currents, carrying up food-matters from the deeper water, have a powerful effect upon the seasonal development of surface plankton. These may be contributory causes or may be effective locally, or on occasions; but it seems probable that a widespread phenomenon of enormous amount such as the vernal increase of phytoplankton must depend upon an equally widespread and powerfully-acting cause such as the rapid increase in the amount of solar light energy which marks the lengthening days of the year in early spring.

NOTES ON *Calamopitys*, Unger. By D. H. SCOTT, F.R.S., F.L.S.

(PLATES 6–8 and one Text-figure.)

[Read 15th November, 1917.]

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INTRODUCTION.

FIVE species of *Calamopitys*, of Lower Carboniferous or possibly in some cases of Upper Devonian age, have been described: two, *C. Saturni*, Unger and *C. annularis* (Unger), from Thuringia (Unger, 1856; Solms, 1896); one, *C. Beinertiana* (Goepp.) from Silesia and from Scotland (Solms, 1893; Scott, 1902); one, *C. fascicularis*, Scott, from Scotland and England (Scott, 1902); and one, *C. americana*, Scott & Jeffrey, from the State of Kentucky (Scott & Jeffrey, 1914).

The two species *C. Beinertiana* and *C. fascicularis*, which I was responsible for referring to *Calamopitys*, have been placed by Dr. Zalessky in a separate genus, *Eristophyton* (Zalessky, 1911). The object of the present Notes is firstly to put on record some fresh evidence as to the course of the leaf-trace in *C. americana*, and secondly to discuss the relations of the various species, with special reference to Dr. Zalessky's proposed division of the genus.

It will be remembered that *Calamopitys* is a genus of Cycadofilices *, with a stem-structure comparable to that of *Lyginopteris*, for the pith is surrounded by a ring of mesarch primary strands of xylem. Their structure, however, is usually more centrally mesarch than in *Lyginopteris*. The leaf-trace is a single strand at its origin, but divides further out, in all cases

* Used here in preference to "Pteridosperms" because there is no evidence whatever as to the fructification.

where its course has been followed. Secondary wood is present, often reaching a considerable thickness. The secondary and metaxylem tracheides have multiseriate bordered pits.

In three species, *C. Saturni, C. annularis*, and *C. americana*, the leaf-bases are present and have the structure of *Kalymma*, containing a number of bundles derived from the subdivision of a single leaf-trace.

In *C. americana*, and probably in *C. annularis*, the pith is a "mixed" one, containing tracheides, and the structure therefore protostelic (Scott & Jeffrey, 1914, p. 318). The differences between the species will be discussed in the second part of the paper.

I. The Leaf-trace of *Calamopitys americana*.

In the paper, by Prof. Jeffrey and myself, on Fossil Plants from Kentucky, we showed that in *C. americana* the leaf-trace, starting as a single bundle, divides into two as it passes through the zone of secondary wood, thus entering the cortex as two distinct strands (Scott & Jeffrey, 1914, p. 321). Certain difficulties, however, remained. In one case the original bundle was found to divide twice, and there was some doubt as to the nature of the first division, though it seemed probable that it served to separate the trace as a whole from a reparatory strand which remained in the stele, while the second division represented the duplication of the trace itself (*l. c.* p. 323). Neither had we, at that time, any section clearly showing the two bundles of the trace where they pass out of the secondary wood.

I have since had a new series of sections cut for me by Mr. Hemingway, which shows the whole process of division of the trace quite clearly, as well as its relation to the reparatory strand. The new evidence only confirms our previous conclusions, but it makes the case clear, where it was obscure before, and therefore seems worth bringing forward.

The fragment from which the new series was cut was about an inch long, and 20 transverse sections were obtained from it. It forms a portion of the stem marked F, one of the larger specimens, the whole stem measuring about 40 mm., with a pith about 13 mm. in diameter. The uppermost section of the series lies just below a section previously figured (*l. c.*, Pl. 29. Phot. 22 and Pl. 30. Phot. 28), so that the origin of the two bundles there shown can be followed. In the original section only one bundle was complete, the other fragmentary ; in the new series both are complete, from their first separation onwards. A selection of the slides, illustrating the most important changes, has been photographed (Pl. 6. Phots. 1–10). The series is followed from below upwards.

In the lowest section (Phot. 1) the trace in question is still at the margin of the "pith" ; it has only just begun to move outwards, but its nature, as an outgoing trace, is indicated by the fan-like arrangement of the rows of

secondary tracheides radiating out from it, and starting from its flanks as well as from the abaxial side. The protoxylem is disorganized but its position is evident (Phot. 2); it lies deep in the interior of the xylem-strand, nearer the outer than the inner edge. It will be noticed that the elements lying on the inner side of the protoxylem are decidedly larger than those towards the exterior. On the inner side the xylem-strand is not sharply delimited, for the pith was "mixed," and also there was some connection with a reparatory strand, better shown in a later section.

The next section shows little change. In section 3 (Phot. 3) the outward progress is still very slight. The protoxylem of the outgoing strand appears to have divided into two, so far as the imperfect preservation of this part permits one to judge (Phot. 4). The most interesting point in this section, however, is that the connection of the leaf-trace with a strand remaining in the stele is clearly shown. This strand lies on the inner side of the xylem of the trace and somewhat to one side (Phot. 4). Its protoxylem is evident (though a wide crack passes through it). The two strands are clearly in the act of separating. The structure is almost identical with that shown, from another specimen, in Pl. 35. fig. 4 of the Kentucky paper (Scott & Jeffrey, 1914). The new evidence completely confirms the interpretation there suggested, that the division in question "separated the trace as a whole from a reparatory strand which did not immediately pass out" (p. 325).

Two sections higher up (Phot. 5) the connection between the reparatory strand and the leaf-trace is almost severed. Though the xylem-strand of the trace is damaged, the two distinct protoxylem-groups are now evident, and there are signs of a division of the centripetal portion of the xylem.

In the following four sections the outward movement of the leaf-trace is very slow, but the gradual division of the xylem into two becomes more marked (see Phot. 6, from the 9th section). So far, however, it is only the inner part of the strand that is affected, while the outer, centrifugal, portion is still continuous. Even in the former, the separation appears wider than it actually was, owing to decay of some of the elements.

In the succeeding sections the fan of secondary wood corresponding to the trace broadens out, the lateral rows making a wider curve. At the same time the primary xylem is completing its division. In Phot. 7, from section 13, the two distinct strands are evident, though perhaps still slightly connected on the abaxial side. The radial series of the secondary wood here begin to show an arrangement corresponding to the doubling of the primary strand, the original fan tending to resolve itself into two fans, as shown by the slight opposite curvature of the adjacent median rows (Phot. 7).

The two strands of the leaf-trace now rapidly separate, and the outward movement also becomes more marked. In the 15th section (Phot. 8) the strands are separated by more than their own width and their protoxylem centres are about 2·5 mm. apart. At this level a median band of secondary

wood abuts on the tissue separating the two strands and appears to belong to neither : ultimately, however, this also is divided between them.

Two sections further up (section 17, Phot. 9) the two strands are completely organized as separate bundles, each with its own arc of secondary wood ; the rows of the wood spring from both flanks of either strand, and are beginning to extend further inwards. The protoxylem-groups are here over 3 mm. apart, the clear distance between the two primary strands being nearly 2·5 mm. A wide ray is appearing between the two fans of secondary wood.

In the next two sections rows of secondary wood appear between the two bundles of the trace, and in the bundles themselves the secondary growth begins to extend to the inner, adaxial side. Lastly, in the uppermost section of the series (section 20, Phot. 10) there is a considerable tract of secondary wood between the two strands extending far to the inside. It is also closing in directly behind the right-hand (upper) bundle. In this strand the secondary wood proper to the strand now clearly extends all round, the rows on the adaxial side still being short. In the left-hand (lower) strand the adaxial wood is less evident, but this may be merely a matter of preservation. The right-hand bundle lies beyond the limits of the adjacent secondary wood, while that on the left appears to be less far out.

In each bundle the primary xylem is radially elongated, an appearance no doubt due in some degree to the oblique course of the outgoing trace. The protoxylem, here as in the original single strand, lies somewhat nearer the outer than the inner edge: it may be beginning to divide, but this is doubtful.

The section last described comes next below that already figured in the Kentucky paper (Scott & Jeffrey, 1914, Pl. 29. Phot. 22 ; Pl. 30. Phot. 28). This section is reversed as compared with those of the new series; the complete bundle shown in the former corresponds to the left-hand (lower) strand in the photographs now given. The chief changes are that the secondary wood of the stele has at the higher level completely closed in behind this strand and the strand itself has well-developed wood all round it, as described in the Kentucky paper (p. 324). The companion strand (the right-hand (upper) one in the new series, left-hand in the 1914 figure) is only represented by a fragment in the old section.

The series just described demonstrates, with perfect clearness, the division of the leaf-trace into two equivalent strands as it passes out through the secondary wood. The latter, however, is a late formation, and a better way of expressing the facts is to say that the trace divided before reaching the pericycle : *i. e.*, while still within the zone of thickening. In this it differs from the leaf-trace of *C. Saturni*, which, according to the detailed observations of Solms-Laubach, passed beyond the woody zone as a single bundle, and only divided into two in the cortex (Solms, 1896, pp. 67, 69 ; Taf. 4. figs. 1–3). The difference, however, is not very great. Solms-Laubach

states (p. 68) that the primary strand of the leaf-trace where it separates from the wood has two protoxylem-groups, placed near the ends of the transverse section ; his fig. 8 (Taf. 4) shows a leaf-trace still in the woody zone of the stele and showing two most distinct protoxylem-groups ; the reparatory strand lies behind, and the whole appearance is remarkably like some of our own sections (Phots. 4–6). The distinction is simply that in *C. americana* the division of the trace is completed somewhat earlier in its course than in *C. Saturni*. In the latter species, as in ours, the leaf-trace had its own secondary wood, where it first became separate, but it is described as limited to the outer side (p. 68).

It need hardly be pointed out that the evidence from the new series of sections finally disposes of the suggestion that the outgoing bundles with secondary growth might be the steles of branches. A single strand from the peripheral ring passes out and divides, exactly in the manner of a leaf-trace and in a way perfectly comparable to that already observed in the undoubted leaf-traces of *Calamopitys Saturni.*

II. The Genus *Calamopitys.*

A comparative survey of the species which have been included in this genus is required, now that our knowledge has been extended by the discovery of a new form, *Calamopitys americana*, while a division of the genus has been proposed by Dr. Zalessky, on grounds which demand consideration.

The genus *Calamopitys* was established by Unger in 1856 on the species *C. Saturni* from Saalfeld in Thuringia. Our knowledge of the true structure of the type species is entirely due to Count Solms-Laubach (1896), who added a second species, *C. annularis*, which Unger had described as a *Stigmaria.* These two species have hitherto been regarded as very closely allied, perhaps not even truly distinct. I find, however, considerable differences between them ; *C. annularis* very closely approaches the Kentucky species *C. americana,* while *C. Saturni* is in some respects more like *C. fascicularis,* one of the two species separated by Zalessky under the name *Eristophyton.*

C. annularis appears never to have been figured since the time of Unger, who quite misunderstood its structure. I happen to have in my hands several sections of this species, as well as two of *C. Saturni*, all lent to me by the late Count Solms-Laubach some years ago, for comparison with *C. americana.* I have taken advantage of this fortunate circumstance to re-investigate the structure, so far as my limited material allows—it is not likely to be added to in the near future. For *C. annularis* the available sections are fairly adequate, and I have thought it well to give some figures of this imperfectly known species as well as one or two additional illustrations of the more familiar *C. Saturni.*

I propose to begin with *C. annularis*, which stands most in need of further elucidation, though I may say at once that my observations in almost every respect confirm the brief account given by Solms-Laubach, so far as it goes.

Calamopitys annularis (Unger), Solms.

The available sections of this species are from three specimens (besides a doubtful one), two of which (Berlin, 97 & 98) are described by Solms-Laubach (1896, p. 75) as among the most indubitable examples *.

Specimen 97 shows the general structure best. The two transverse sections are cut quite close together, and show no important change of structure. Section 97 appears to come just above 40*a*.

The diameter of the stele, measured to the outside of the secondary wood, is about 20 mm.; that of the pith, including the primary wood, 6–7 mm. The phloem is badly preserved, but a large piece of the cortex, or leaf-base, quite 1 cm. thick, is attached. This shows the *Kalymma* structure, already described by Solms-Laubach (Pl. 7, Phot. 11).

The primary xylem appears to be continuous or nearly so. The preservation is far from perfect, but the tracheides can generally be recognized by their thickened and pitted walls; the pith is almost everywhere surrounded by a band, several layers thick, of such elements; there may have been occasional small gaps filled by parenchyma. The primary xylem-strands are not very well defined; judging from the frequency of protoxylem-like groups of small elements, they must have been very numerous—perhaps as many as 20 (see Phots. 12–14). As a rule, the strands are eccentrically mesarch, the protoxylem lying decidedly nearer the outer than the inner edge; in these cases there is usually a marked difference between the centripetal and centrifugal portion of the xylem, the former consisting of larger tracheides than the latter (see Phot. 13). In both

* The sections examined are as follows:—

1. Specimen, Berlin, 97.

Two almost identical transverse sections, labelled: "97 Stigmaria annularis. Saalfeld. Richter. (Berl. Ldes. Anst. 97-1)." "40*a*. Stigm. annul. Culm Saalfeld. Coll. Solms 413."

One radial section, labelled: "97R. Calamop. ann. Berlin Landesanst. Coll. Solms. n. 413."

2. Specimen, Berlin, 98.

One transverse section only, labelled: "98 Stigmaria annularis. Saalfeld Richter. Berlin Landesanst. Coll. Solms. n. 411."

3. Specimen, Halle, 761.

One transverse section, labelled; "761. Cal. annul. 9. Mus. Hal. Coll. Solms. n. 420."

4. Specimen, Berlin, 49.

One radial section labelled: "49R. Stigm. ann. Culm Saalfeld. Berl. Ldesanst. Coll. Solms. n. 421."

I am not sure that this isolated section is rightly named, and have taken no account of it in the text.

respects the xylem-strands of *C. annularis* agree with those of *C. americana* (see Phots. 2 & 4; also Scott & Jeffrey, 1914, Pl. 35. figs. 1, 2, 4; Pl. 36. fig. 5). In other strands the structure is less eccentric, and there is correspondingly less differentiation between the inner and outer portions of the xylem (Phot. 14). The xylem-strands which are in closest contact with the secondary wood have the most eccentric structure; conversely, those which are more nearly centrally mesarch stand a little further back, and even, in some cases, appear to be separated from the secondary wood by a layer or two of parenchyma.

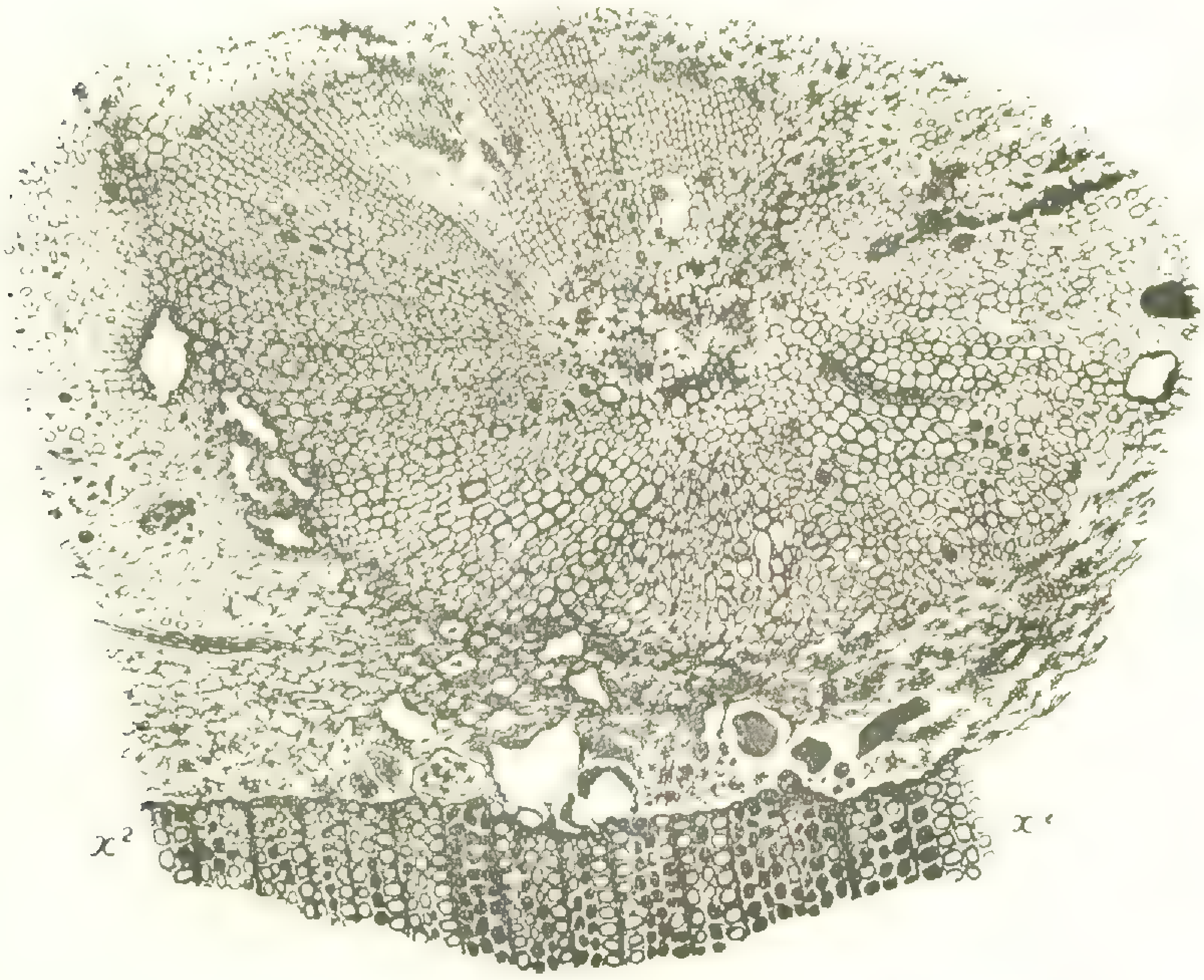
It was mentioned in the paper by Prof. Jeffrey and myself (*l. c.* p. 326) that there is evidence for the occurrence of medullary tracheides in *C. annularis*, as in *C. americana*. I have carefully looked into this question. In transverse sections one can distinguish at a few places elements with thicker walls than the ordinary parenchyma, and resembling the tracheides of the xylem-ring. But the preservation is not such as to make these indications at all convincing. The longitudinal section of specimen 97 passes through the middle of the pith as shown by the dimensions. Several tubes are seen embedded in the medullary parenchyma; they are of very various diameters, ranging from about 100 to about 360 μ—the larger are probably distorted (Phot. 15). The smaller tubes agree very well in shape and dimensions with those in the pith of *C. americana* (Scott & Jeffrey, 1914, Pl. 34. Phot. 51; Pl. 36. fig. 8). These tubes appear to have a wall of their own (Phot. 16), but pits have not been observed. There is a strong presumption that these elements are medullary tracheides, but better evidence is required. Similar tubes occur in the pith of the only other specimen under the name *C. annularis* of which I have a radial section. This will be described below.

As regards the secondary wood there is not much to be said. The medullary rays are multiseriate, but not dilated outwards (Phot. 12). In radial section they are muriform, with narrow cells. The secondary tracheides are much smaller than the large elements of the primary xylem—about 60 μ in the former to 100 μ in the latter. The radial section shows the pits in 3–6 series; the arrangement in horizontal or slightly oblique ranks is fairly regular; longitudinally, the pits may either be alternate or in irregular vertical series. Their form is commonly somewhat elliptical or at least elongated in the transverse direction. In all these respects the structure agrees with that of *C. Saturni* and *C. americana*.

The sections at my disposal give little information as to the mode of exit of the leaf-traces. In specimen 97 there is at one point a disturbance in the regularity of the wood, no doubt connected with a leaf-trace (see Phots. 11 and 12). Two segments of the secondary wood are somewhat prominent, with a convex outer edge; between them the tissue is badly preserved, but there was evidently a median wedge of wood, not extending so far out as its

two neighbours (Phot. 12). There is a primary xylem-strand corresponding to each of the three secondary wedges; the median strand (not well preserved) begins further out from the pith than the other two and presumably alone represents the leaf-trace (Phot. 13, *l.t.*). The structure is comparable to that shown in *C. americana* : see, for example, Pl. 6, Phot. 5. The secondary wedge corresponding to the trace is however narrower in *C. annularis*. One of the adjacent strands lies nearly behind the leaf-trace, and may well be the reparatory strand from which it has separated (Pl. 7, Phot. 13). Unfortunately there are no sections available to show the outward progress

Text-figure 1.



Calamopitys annularis (Unger), Solms.

Transverse section of leaf-trace strand, shown at *l.t.* in Phot. 18. x^2, outer edge of secondary wood of stele. The strand shows the ill-preserved primary xylem in the middle, surrounded by a broad secondary zone. × about 18. Drawn by Mr. G. T. Gwilliam. Section 98, Berlin. (Coll. Solms 411).

of the trace; the next phase shown (in another specimen) is beyond the wood altogether (Phot. 18).

This is in specimen 98. The stele, measured to the outside of the wood, is 28 × 21 mm. in diameter and the pith (including primary xylem) about 8–9 mm. On one side a portion of cortical tissue is attached, which probably formed part of a leaf-base.

The pith itself is destroyed; the primary wood is imperfect, but enough remains to show that it formed a very nearly continuous zone. Where the

structure of the individual strands can be made out it is very eccentrically mesarch, with the centrifugal part of the xylem much reduced as compared with the centripetal.

The leaf-trace above referred to lies outside the wood, probably in the pericycle, to one side of the fragment of leaf-base (Phot. 18, Text-figure 1). It is a large strand, measuring about 4·5 × 2·6 mm. in diameter, the longer axis being tangential to the stem. The greater part is composed of secondary wood, which is well developed all round the strand, and is thickest on the flanks. Very little of the primary xylem at the centre is preserved. A similar strand is mentioned in this specimen by Solms-Laubach (1896, p. 74), who, however, describes the secondary growth as feeble and limited to the outer side, forming an arc. In our case, the secondary wood forms a wide zone, and seems to be about equally developed on the outer and inner face of the strand (Text-fig. 1). The structure is obviously comparable to that of a leaf-trace bundle of *C. americana*, in the corresponding position (*cf.* Phot. 10).

On one side of the strand there is an irregular extension of the wood, seen partly in oblique section. I am doubtful as to its nature; it is possible that it may represent the other bundle of the trace, the two strands having been crushed together; this part of the tissue has a macerated appearance, and is less well preserved than the stele and leaf-base. There is another bundle, on the opposite side of the fragment of leaf-base, which appears to correspond more nearly with Solms-Laubach's description, but the preservation is bad.

In the cortex or leaf-base itself two complete bundles are preserved, as described by Solms-Laubach (p. 75). Each is elongated, approximately in the radial plane *, and has three internal protoxylem-groups, the latter lying towards that side of the strand which faces its neighbour. There is, of course, no secondary thickening at this level. The structure is identical with that of the bundle figured by Solms-Laubach from *C. Saturni* (*l. c.* Taf. 4. fig. 11) and also agrees with that of the bundles in the leaf-base and petiole of *C. americana* (Scott & Jeffrey, 1914; Pl. 27. Phots. 4, 5; Pl. 36. fig. 9). A small part of the Sparganum hypoderma is preserved. The whole structure is that of a *Kalymma*, as Solms-Laubach has shown. From the form and arrangement of the bundles it seems evident that the fragment formed part of a leaf-base, rather than of the mere cortex of the stem.

The same probably holds good for the fragment attached to specimen 97, which shows essentially the same structure (Phot. 11). Here the bundles have from two to four protoxylem-groups; there appear to be three in the one figured (Phot. 17). Two of the bundles are giving off smaller branches, with a single protoxylem.

As regards the structure of the leaf-base, the three species, *C. annularis*, *C. Saturni*, and *C. americana*, seem to be practically identical.

* The fragment is obviously displaced (see Phot. 18).

The Halle specimen under the name *C. annularis* (Solms, 420) is remarkable for two features—the narrowness of the medullary rays and the smallness of the pith. The specimen (Phot. 19) includes the whole of the latter and a large portion of the wood, but probably not its full thickness. The present radius is about 14 mm.

The pith, including the primary xylem, only measures about 2·5 × 1·7 mm. (Phots. 19, 20). No stems of *C. annularis* with a small pith like this are mentioned by Solms-Laubach, so presumably this specimen only came under observation after his paper was published. The question arises, is it rightly named *Calamopitys annularis?* The primary xylem forms an irregular zone in which some of the strands are fairly well defined, but appear to be connected by intermediate tracheides. At some places the xylem forms a continuous band, while elsewhere there are only scattered tracheides between the primary strands; this difference may simply be due to unequal preservation. It is extremely difficult to make out any protoxylem in the primary strands; where elements smaller than the rest occur, they lie towards the outer edge of the strand (Phot. 20).

The pith is badly preserved; a certain number of largish elements, with somewhat thick walls and clear lumina, persist and suggest tracheides (Phot. 20). The radial section confirms this suggestion. This section extends right across the pith, which contains many long tubes, agreeing in appearance and size with the tracheides of the primary wood. In the case of a stem with so small a pith one cannot be certain that the section, though apparently radial, may not be sufficiently tangential to the pith to pass through the inner part of the xylem-ring. However, it is probable that some of the more scattered tubes really represent medullary tracheides.

The secondary wood is remarkable, for it nowhere shows the wide medullary rays characteristic of the species. Most of the rays seen in transverse section are uniseriate; about half as many are biseriate; larger numbers (locally four rows of cells were seen in a single case) are extremely rare. There is no tangential section of the specimen, but one may conjecture that the ray in this form commonly had a middle portion two rows wide, with a uniseriate extension above and below. The whole appearance of the wood is very different from that of the typical *C. annularis* (*cf.* Phots. 12, 18). The rays are also very narrow in actual dimensions, the single ray-cell being commonly about 12 μ wide.

The secondary tracheides are small; a rough average giving about 36 μ for the diameter. Consequently the radial section shows few rows of pits on the wall; usually they are in 1–3 rows, rarely 4. Otherwise they appear to agree with the pits of the first specimen.

The Halle stem is obviously different in certain points from the typical form of the species. It is certainly not *C. Saturni*, for, as will be seen presently, a specimen of that plant of about the same dimensions as regards

the pith, shows totally different characters. I think it most probable that the Halle specimen was rightly named by Solms-Laubach and that it represents an advanced stage of a small branch, with the structure somewhat modified as compared with that of the main stems. In spite of the peculiarities mentioned, the general character of the tissues suggests *Calamopitys annularis* and no other plant.

The special features which require to be emphasized in the species *C. annularis* are: 1. The continuous or almost continuous zone of primary xylem (already pointed out by Solms-Laubach).

2. The eccentrically mesarch structure of the xylem-strands, with a corresponding reduction of the centrifugal portion.

3. The *probable* presence of tracheides embedded in the pith.

4. The secondary thickening all round the leaf-trace strand on its exit from the wood.

In all these points *C. annularis* agrees with *C. americana*.

The division of the leaf-trace into two has not been observed in *C. annularis*; there can be no doubt that it takes place, but we do not know in what part of the course of the trace the division occurs. The narrow medullary rays of the Halle specimen, assuming, as seems to be justified, that it is rightly referred to *C. annularis*, are interesting, for comparison with other species.

Calamopitys Saturni, Unger.

This species is well known, from the full and admirable account given in 1896 by Solms-Laubach. It has also been examined by Dr. Zalessky (1911). Solms-Laubach describes the primary wood in this species as "an irregular tracheal zone, perhaps interrupted here and there, which swells out in places into expanded nests, projecting into the pith-parenchyma" (1896, p. 65). In *C. annularis* it seemed to him that the primary wood was "more strongly developed, forming a quite or almost closed ring" (*l.c.* p. 74). Judging from the one transverse section of *C. Saturni* now in my hands, I am inclined to think that the distinction between the two species is more marked than Solms-Laubach realized. This section (Pl. 8. Phots. 21, 22) is from the specimen Berlin, 76, and is among those described by Solms-Laubach (*l. c.* p. 71), but not figured *.

Two excellent photographs from another section of the specimen are, however, given by Dr. Zalessky (1911, Pl. 3. figs. 1, 2). The specimen (stele only) was 1 cm. in diameter; the section here figured is incomplete,

* I have one transverse and one radial section. The former is labelled: "Cal. Sat. Q. Berl. 76. Culm Saalfeld. Berlin Landes Anst. Coll. Solms 422."

The radial section is apparently not from the same specimen, for the inscription is: "29R. Cal. Sat. ? r. Culm Saalfeld. Berlin Ldesanst. Coll. Solms n. 423." The ? makes the value of this section doubtful, though it was sent to me by Count Solms as an example of the species *C. Saturni* and a tangential section of no. 29 is figured by Dr. Zalessky under that name.

but shows the whole of the pith and primary wood ; the preservation is remarkably good (Phots. 21 & 22). The pith is quite small, about 1·8 × 1·4 mm. in diameter, including the primary wood.

Around the pith there are six distinct primary xylem-strands ; in addition there is a seventh strand entering the wood, and lying immediately outside one of the circum-medullary strands (Phot. 22). The latter stands rather further back in the pith than usual, but at this level is scarcely, if at all, separate from the outgoing strand. The pair presumably represents a leaf-trace with its reparatory strand.

The first point that strikes one about the primary xylem-strands, as compared with those of *C. annularis*, is that they are almost circular in section and *centrally* mesarch ; the protoxylem is in the middle of the strand ; the centrifugal portion is just as well developed as the centripetal, and has equally large elements (Phot. 22). This holds good without any qualification for five out of the seven strands ; only in the strand entering the wood, and in a less degree in one other, also partly embedded in it, is there any reduction of the centrifugal primary xylem. In these two cases it may be to some extent merged in the secondary layers, as we found in the case of *Archæopitys Eastmanii* (Scott & Jeffrey, 1914, p. 347 ; Pl. 38. fig. 17). The predominance of centrally mesarch structure is a striking contrast to *C. annularis* and *C. americana*, and a striking point of agreement with *C. fascicularis* and *C. Beinertiana*, so far as the large xylem-strands of the latter two species are concerned.

Another point about the xylem-strands in this specimen of *C. Saturni* is that they are quite well defined and to all appearance perfectly separate from one another. In no case (except of course that of the leaf-trace and its reparatory strand) have I found any sign of continuity between the bundles. The perfect preservation allows the tracheides with their somewhat thick and distinctly pitted walls to stand out quite clearly from the thin-walled parenchymatous cells* of the pith. In every case the xylem-strand forms a definite, more or less circular group of tracheides, while the whole of the tissue lying between the strands, whether the intervals be broad or narrow, is parenchymatous and identical with that of the pith (see Phot. 22 ; also Zalessky, 1911, Pl. 3. figs. 1, 2). The bundles are, in fact, just as distinct as in *Lyginopteris* or *Poroxylon* ; there is no sign of a continuous xylem-ring.

The whole of the pith appears to consist of thin-walled parenchyma. Every cell is preserved and I find no indication of medullary tracheides, except in one doubtful case, in the outer part of the pith. If present at all, the medullary tracheides must here have been in the last stage of reduction.

* The wall (or middle lamella?) appears as a clear thin line with irregular deposits of a dark substance on either side.

Dr. Zalessky gives photographic figures of another section of the same specimen (*l. c.* Pl. 3. figs. 1, 2). This was evidently cut near the one I have, for all the bundles can be identified (*cf.* Phot. 22). Both Dr. Zalessky (*l. c.* p. 25) and Solms-Laubach (*l. c.* p. 72) mention in this case a single bundle embedded in the pith, at a little distance from the secondary wood. From the former author's photograph (*l. c.* fig. 2) it is clear that this bundle is the reparatory strand of the leaf-trace. The leaf-trace itself is here more embedded in the secondary wood and does not seem to have been noticed. Presumably the section photographed by Dr. Zalessky was cut just above ours, at a point where the separation of the leaf-trace from the reparatory strand was more complete.

In the section figured in the present paper there is another bundle (Phot. 22, *x*), which appears to be embedded in the pith; unfortunately the secondary wood has been cut away at this point, but about three layers of cells remaining on the outer side of the strand are clearly parenchymatous. The strand in question is identical with the left-hand one of the two shown in Dr. Zalessky's fig. 2. In his section it appears to be almost in contact with the secondary wood. It does not seem to be a reparatory strand, for no leaf-trace is visible.

In the circular form and centrally mesarch structure of most of the xylem-strands, as well as in their complete isolation from one another, *C. Saturni*, to judge from this specimen, differs sharply from *C. annularis* and *C. americana*. There is no reason to doubt that the specimen described is typical of the species in these respects, though in other sections, which I examined in 1901, the exact limits of the xylem-strands were more difficult to trace, owing to the nature of the preservation.

Another probable difference is in the occurrence of medullary tracheides, which are a characteristic feature of *C. americana* and appear to be frequent in *C. annularis*, while there is little or no evidence for their presence in *C. Saturni*. This, if established, would be an important distinctive character, but as regards the two Thuringian species the data are inadequate for a final decision. One small point remains to be mentioned: in our specimen of *C. Saturni* and in some others the medullary rays are often dilated outwards, as noticed by Dr. Zalessky (*l. c.* p. 26), while this is not the case in *C. annularis* or *C. americana*. This character is obviously of only specific value, at most.

The question of the course of the leaf-trace has been discussed above (p. 208), and the distinction in this respect between *C. Saturni* and *C. americana* pointed out; the data are wanting for a comparison with *C. annularis*. On the other hand, the structure of the leaf-trace on its exit from the secondary wood is very much the same in the last-named species and *C. americana*.

On the whole of the characters available for comparison, it seems clear that *C. Saturni* is very distinct from *C. annularis* and *C. americana*, while the two latter species show a remarkably close agreement with one another.

Calamopitys americana, Scott & Jeffrey.

A short summary of the chief characters of this species is all that need be given here.

Primary xylem-strands eccentrically mesarch, with the centrifugal portion smaller and smaller-celled than the centripetal. Strands united laterally to form an almost closed xylem-ring.

Pith "mixed," containing a varying proportion of medullary tracheides.

Leaf-trace dividing into two as it passes through the secondary wood. Each leaf-trace bundle, where it leaves the wood, surrounded by a zone of secondary thickening.

Secondary wood with high, multiseriate medullary rays, not enlarged outwards. Tracheides with several series of alternating bordered pits on the radial walls.

Leaf-base with the structure of *Kalymma*, containing a number of mesarch bundles, each with from 2 to 5 protoxylem-groups.

The details are fully described in the paper by Prof. Jeffrey and myself (1914), supplemented by the more complete account of the course of the leaf-trace given in the first part of the present communication.

Calamopitys fascicularis, Scott.

Eristophyton fasciculare, Zalessky.

This species was shortly described, under the name *Araucarioxylon fasciculare*, in 1899 (Scott, 1899, p. 615) and a full illustrated account was given three years later, when I placed it in the genus *Calamopitys* (Scott, 1902, p. 332). No new specimens have come to light since then and there is little to add to the published description. The species is mentioned and a figure given by Dr. Zalessky (1911, p. 23 ; Pl. 3. fig. 7), who contests its affinity with *Calamopitys* and transfers the plant to his new genus *Eristophyton*. A brief recapitulation of the principal features may be given here, reserving the discussion of the systematic position to the conclusion of the paper.

The pith is small (2–3 mm. in diameter) and of very uniform parenchymatous structure ; it contains no sclerotic nests. A few of the cells have dark contents and may possibly have been secretory in function. There are no medullary tracheides.

The pith is surrounded by a ring of about 8 or 9 primary xylem-strands, of mesarch structure (Scott, 1902 ; Pl. 3. fig. 1). They are of very unequal size. Those which are about to enter the secondary wood as leaf-traces are very large, from 0·8 to 1 mm. in diameter. Those cut lower down in their course are much smaller, diminishing rapidly as

they pass down in the pith, to a diameter of 0·25 mm. and less. The smaller strands are as a rule embedded in the pith, a few layers of parenchyma separating them from the secondary wood (*l.c.* Pl. 3. fig. 2). The large, outgoing strands are centrally mesarch, like those of *C. Saturni* (*l.c.* Pl. 1. Phot. 2); the smaller strands, forming their downward continuation, become eccentrically mesarch with the protoxylem towards the inner side, and may even approach an endarch structure.

The course of the leaf-traces has been followed in successive transverse sections; the phyllotaxis is 2/5, with short internodes; each leaf-trace, as it passes down in the pith, eventually unites with a reparatory strand on its kathodic side (*l. c.*, Diagrams 1–4).

In the outgoing trace, as it enters the secondary wood, the protoxylem divides into two groups, which may become widely separated (Phot. 23). The division of the trace as a whole has not been observed, and probably took place too far out to be shown in the incomplete specimens alone available.

The secondary wood has essentially a Cordaitean structure, with medullary rays one cell or locally two cells in width, and of no great height (Scott, *l. c.* Pl. 4. fig. 6). The tracheides have from two to four rows of bordered pits on the radial wall; the pits are arranged in more regular vertical rows than in the three previous species; in the form of the pits there is little difference, for in *C. fascicularis*, though often isodiametric, they are about as frequently elongated in the transverse direction. The pits of adjacent rows alternate regularly and are in close contact with one another, so that their outline is more or less hexagonal (*l.c.* Pl. 3. figs. 4, 5).

The inner layers of the secondary wood are peculiar, for they consist largely of short, wide tracheides with numerous irregular rows of pits (*l.c.* Pl. 3. fig. 3). In this region the medullary rays are also dilated and distorted.

It is evident that this species differs in several respects from any of those previously considered. The significance of these differences will be discussed after the next and last species has been dealt with.

Calamopitys Beinertiana (Goeppert), Scott.

Eristophyton Beinertianum (Goeppert), Zalessky.

This is the old *Araucarites Beinertianus* of Goeppert *.

The primary wood was first described in 1902 (Scott, 1902, p. 341), and the characters then observed led me to place the species in the genus *Calamopitys*, side by side with *C. fascicularis*.

The figures given in the paper of 1902 have since been supplemented by five excellent photographs from Solms-Laubach's Falkenberg specimen, published

* For synonyms and references, see Scott, 1902, p. 344 footnote.

by Dr. Zalessky (1911, Pl. 3. figs. 3–6*a*). This author associates the species with *C. fascicularis* in his genus *Eristophyton*. Two specimens have come under observation, Solms-Laubach's stem from Silesia and the British one collected by Dr. Kidston at Norham Bridge on the Tweed. For the purposes of the present paper I have also examined sections, kindly lent to me by Dr. Kidston and Dr. Gordon, of a specimen received by the former from Mr. Dunlop, and also derived from the Norham Bridge locality. This fragment agrees so closely in dimensions, appearance, and state of preservation with the original Tweed specimen, that I think it must be a part of the same stem. The new sections have afforded some fresh data for the study of the leaf-traces.

Except for a fragment of bark, the specimens investigated include only the pith and wood. The characters of the species are briefly as follows :—

The pith is large, 13–15 mm. in diameter in the British specimens and about 8 mm. in that from Falkenberg. A striking feature of the pith is the presence of sclerotic nests, with radiating cell-rows around them (Phot. 27), recalling the similar structures in *Lyginopteris*. This character is entirely absent in *C. fascicularis* and in all the other species referred to the genus. There are no medullary tracheides. Around the pith and in contact with the secondary wood, numerous primary xylem-strands, sometimes confluent with one another, are disposed. These strands show the same variation in size as those of *C. fascicularis*, the maximum diameter being attained as the strand begins to pass out into the secondary wood. The xylem-strands, owing to the large size of the pith, appear less important than in the preceding species, but their absolute dimensions are not much less, the outgoing strands reaching a diameter of 0·8 mm. In this part of their course they are centrally mesarch ; lower down, as the strand diminishes in size, the centripetal portion becomes reduced, and an endarch structure is assumed. Strands in three different phases are shown, from the Falkenberg specimen, in Phots. 24–26. The first is a large strand just entering the wood, with centrally mesarch structure *. Phot. 25 shows a bundle lower down in its course, reduced in size, but still mesarch, while in Phot. 26 we see a strand at a still lower level, very small, and distinctly endarch in structure. These changes are quite parallel to those in the xylem-strands of *C. fascicularis*, but in *C. Beinertiana* they go further, the centripetal xylem dying out altogether.

The new sections of the British specimen show the leaf-traces at various points in their passage through the secondary wood. Three such traces may appear in the same transverse section (Phot. 27), so the internodes must have been short, for the trace, after leaving the pith, curves rapidly outwards, so as to be cut very obliquely in transverse sections of the wood. I have not

* There is a group of small elements suggesting a second protoxylem in an exarch position. I have not seen this elsewhere and cannot offer any explanation. This strand and the endarch one have already been figured by Zalessky (1911, Pl. 3. Phots. 4, 5, 6, 6*a*).

been able to determine the phyllotaxis. In the section figured (Phot. 27) two traces in almost the same phase (about 2 mm. from the pith) are nearly opposite each other; the arrangement, however, was certainly not decussate or distichous, as shown by the position of other traces. Probably it was a fairly complex spiral.

I have seen no certain case of the division of the protoxylem in the outgoing leaf-trace. The strand shown in Phot. 28, cut almost transversely in a tangential section of the wood, appears to have a single median protoxylem.

The secondary wood, as in *C. fascicularis*, has a Cordaitean character, with the medullary rays seldom more than one cell in width (Scott, 1902, Pl. 4. fig. 12). The pits of the secondary tracheides are most often in two rows, sometimes in a single row; they are often scattered, and even when in contact, do not always show an hexagonal form. Those of the primary elements are in numerous irregular rows (*l. c.* Pl. 4. fig. 11).

The species *C. Beinertiana* clearly has much in common with *C. fascicularis*, though the large size and peculiar structure of the pith give it a very different anatomical habit. Both species have advanced further in a Gymnospermous direction than the three first described, and, of the two, *C. Beinertiana* shows the greater progress.

Synopsis.

A concise synopsis of the chief characters of the five species may be of service for reference.

1. Xylem-strands of fairly uniform size, all mesarch.
   Rays usually multiseriate.
   Petiole with *Kalymma* structure.
   A. Xylem-strands usually eccentrically mesarch, with protoxylem outwards, connected to form a nearly continuous zone. Medullary tracheides present *.
      C. americana (from Kentucky).
      C. annularis † (from Central Germany).
   B. Xylem-strands usually centrally mesarch; quite separate from one another. Medullary tracheides probably absent. *C. Saturni.*
2. Xylem-strands of very unequal size; large and centrally mesarch in the upper part of their course, becoming small and nearly or quite endarch lower down.
   Rays usually uniseriate.
   (Petiole unknown.)

* Proved for *C. americana*; highly probable for *C. annularis.*

† It would be premature to give distinctive characters at present. In the meantime the localities prevent any confusion.

α. *C. fascicularis.* Pith small, with no sclerotic nests.
Smaller xylem-strands embedded in the pith, with their centripetal xylem much reduced.

β. *C. Beinertiana.* Pith large, with conspicuous sclerotic nests.
All xylem-strands in contact with secondary wood. Centripetal xylem dying out in the smaller strands, which thus become endarch.

The course of the leaf-trace has not been included in the synopsis as it is only adequately known in the two species *C. americana* and *C. Saturni;* in the former the first division of the trace takes place in the zone of thickening; in the latter not till the trace has passed beyond this zone.

Affinities of the Species.

We have now to consider the relations of the species among themselves and especially the question of the division of the genus, proposed by Dr. Zalessky. As mentioned above, this author separates the two species, *C. fascicularis* and *C. Beinertiana*, under the generic name *Eristophyton*, leaving in the original genus *C. Saturni* and *C. annularis*; to these the new species *C. americana* must now be added, as its close affinity with *C. annularis* is beyond dispute.

Dr. Zalessky, indeed, goes beyond generic separation, and while admitting a certain analogy and even phylogenetic relation between *Calamopitys* and *Eristophyton** (Zalessky, 1911, p. 27) he points out that the former shows clear affinity to Lyginopterideæ, with some approach to Medulloseæ also, but that no such proximity to *Lyginopteris*† or, in general, to the Cycadofilices is found in the species referred to *Eristophyton* (*l. c.* p. 24). The question at issue is thus an important one and not merely a matter of the definition of genera.

In support of his contention Dr. Zalessky brings forward a number of arguments of very unequal value; while some are of undoubted weight and interest, others are trivial or based on a misconception of the facts. The author goes so far as to state that except for the mesarch xylem-strands everything in the two groups which can be compared appears to differ (*l. c.* p. 25).

To clear the ground it may be well to deal first with the less important arguments, reserving for later consideration the more weighty matters on which I am to a certain extent in agreement with Dr. Zalessky.

He points out that the xylem-strands are rarely embedded in the pith in *Calamopitys Saturni*, while all the smaller strands are so embedded in

* For the sake of clearness I provisionally adopt Dr. Zalessky's nomenclature in discussing his position.

† *Lyginopteris*, Potonié, is the equivalent of *Lyginodendron* as used by Williamson and formerly by myself.

Eristophyton fasciculare. In the other species of *Eristophyton*, however, *E. Beinertianum*, embedding is at least as rare as in the species left in *Calamopitys.* We may cite the small endarch strand shown in Phot. 26, evidently cut low down in its course, but still in contact with the secondary wood. This character varies in both groups, and affords no criterion between them. That it sometimes occurs in *Calamopitys* proper is a point of interest, but not one on which I should lay much stress. Its recurrence in *Pitys* may indicate that it is rather a primitive character. At any rate it does not constitute a difference between *Calamopitys* and *Eristophyton.*

A second argument is based on the structure of the pith. In *Calamopitys*, as the author truly says, the groups of sclerenchymatous cells with dark contents, so conspicuous in *Eristophyton Beinertianum*, are completely absent. But they are likewise absent in the pith of *Eristophyton fasciculare* ; the possible secretory sacs in the latter plant bear no resemblance to the sclerotic nests of *E. Beinertianum* ; the presence of these structures in the pith is a specific and not a generic character, and again affords no distinction between Dr. Zalessky's two genera.

In one other instance this author has attributed generic value to a character which proves to be, at most, only specific. He mentions that in *C. Saturni* some of the medullary rays are gradually enlarged outwards, while this is not the case in the *Eristophyton* species (*l. c.* p. 26). But, as we have seen, it is not the case in *Calamopitys annularis* either, and is therefore of no value as a distinctive character between *Calamopitys* and *Eristophyton.*

The argument from supposed dimensions has been dealt with on a previous occasion (Scott, 1912, p. 1027). Dr. Zalessky estimates that in his *Callixylon Trifilievi*, a plant which he regards as allied to *Eristophyton*, the stem when complete may have attained a diameter of a metre. He thinks it improbable that the stems of Cycadofilices, with their fern-like foliage, should have reached such dimensions. The argument is at best a very indirect one, but I am quite willing to grant that *Eristophyton Beinertianum*, at any rate, is likely to have had a thick stem. If this were so, the fact would not afford the slightest presumption against the plant belonging to the Cycadofilices. Besides the case of *Medullosa stellata*, in which a decorticated stem measured 48 × 45 cm. in diameter (Weber & Sterzel, 1896, p. 25), we may cite that very primitive member of the Cycadofilices *Protopitys Buchiana*, a stem of which, though doubtless incomplete, was also almost a foot and a half thick (Solms-Laubach, 1893, p. 198). The question of dimensions is, in fact, quite irrelevant to the issue.

We now come to Dr. Zalessky's more serious grounds for the separation of *Eristophyton* from *Calamopitys.* The chief of these relate to the structure of the secondary wood. Our author lays great stress on the difference in the medullary rays, high and multiseriate in *Calamopitys*, low and usually uniseriate in *Eristophyton.* The great difference, in typical cases, is strikingly

shown by Dr. Zalessky's comparative figures of the tangential sections of *C. Saturni* and *E. Beinertianum* (*loc. cit.* Pl. 4. figs. 6, 7). There is no doubt that this is, in most specimens, a real and important distinction; the secondary wood of one of the *Eristophyton* species, considered by itself, would at once be assigned to Cordaiteæ, while that of *Calamopitys* proper would suggest one of the Cycadophyta or Cycadofilices. At the same time, if the Halle specimen above described (p. 214) was rightly referred by Solms-Laubach to *C. annularis,* the distinction is inconstant, for in that specimen (a small branch) the rays are about as narrow as in an *Eristophyton.* Neither are small and narrow rays by any means unknown among undoubted Cycadofilices. Thus in *Protopitys Buchiana*, they are low and usually uniseriate, at most 2–3-seriate in the middle (Solms-Laubach, 1893, p. 200, Taf. 6. fig. 4); the same is the case in the polystelic *Cladoxylon Kidstoni* (Solms-Laubach, 1910, Taf. 3. fig. 13) and other species (Solms-Laubach, 1896, p. 55, Taf. 3. fig. 3). In *Pitys* the rays seem to be regularly multiseriate, and this is here accepted as a generic character; their width, however, is extremely variable and in *Callixylon*, which appears to be nearly allied, they are usually uniseriate (Zalessky, 1911, p. 28).

Another point in the structure of the secondary wood on which Dr. Zalessky lays some stress, is the character of the pitting (*l. c.* p. 26, footnote). He finds that in *Eristophyton* the pits are in regular vertical series, while the rows are irregular in *Calamopitys Saturni*; in the former they are regularly hexagonal in form, while in the latter they are elliptical to hexagonal. The fissures, he says, are oblique or horizontal in *Eristophyton*, horizontal in *Calamopitys.* I have already, in describing the species, called attention to the difference in the pitting. As Dr. Zalessky says, the pits of *Calamopitys* are intermediate between those of *Dadoxylon* (Cordaiteæ) and *Lyginopteris,* while in *Eristophyton* they are typically Cordaitean. The difference is a real, if rather a fine one, and is undoubtedly a point in which the wood of *Eristophyton* approaches that of the true Gymnosperms more nearly than is the case in *Calamopitys* proper.

In fact there is no doubt that the species placed by Dr. Zalessky in *Eristophyton* have made, compared with the typical *Calamopitys*, a decided advance in the Gymnospermous direction, as shown, not only in the general structure of the secondary wood, but also in certain features of the primary organization.

These latter points are not much emphasized by Dr. Zalessky, but seem to me to be the most important of all. While in the typical *Calamopitys* species all the primary xylem-strands are more or less uniform in size and similar in structure, in the species referred to *Eristophyton* the strands, as they are followed downwards in the pith, dwindle rapidly in size and tend to assume an endarch rather than a mesarch structure. In *E. fasciculare* there is a near approach to endarchy in the lower part of the strands, while in *E. Beinertianum* this structure is completely attained. I have never observed

any tendency to endarch structure in the xylem-strands of *Calmopitys* proper; where there is any departure from central mesarchy it is in the exarch direction. This seems to me an important difference; it marks a distinct step, in the case of the *Eristophyton* species, towards the ultimate disappearance of the centripetal xylem, which finds its realization in the Coniferous type of stem. If the species in question are to be placed in a separate genus, I should be inclined to rest the distinction rather on the primary characters just discussed, than on the difference in the structure of the secondary wood. The latter hardly affords a constant criterion, unless the case of the Halle specimen, referred to *Calamopitys annularis*, with its narrow medullary rays, can be explained away. I have no objection to generic separation, though I do not, at the moment, adopt it myself. In my first paper I pointed out that the reference of the two species *C. fascicularis* and *C. Beinertiana* to *Calamopitys* must be regarded as provisional until the structure of their cortex and leaf-bases was known (Scott, 1902, pp. 345, 361). This, unfortunately, is not yet the case, and the question is thus still open. If these plants should turn out to have *Kalymma* structure in the leaf-base they should, I think, remain in *Calamopitys*; otherwise their separation will undoubtedly be necessary.

But, on the broader question of the near affinity between the two groups, I think the evidence is very strong. So far as the larger (*i.e.* the outgoing) xylem-strands are concerned the structure of *C. Beinertiana* and *C. fascicularis* is identical with that of *C. Saturni* (compare for example Phot. 22 with Phots. 24 & 25, or with Scott, 1902, Pl. 1. fig. 2). I have seen no xylem-strands of this type, large, circular and centrally mesarch, in any other group of plants. The agreement with *C. annularis* and *C. americana* is less close, for in these species the xylem-strands are as a rule somewhat eccentrically mesarch with the protoxylem nearer the outer side. In fact the species form a kind of series, as shown in the synopsis on p. 221; *C. annularis* and *C. americana* retain much of the protostelic structure, with an almost continuous primary xylem-ring and medullary tracheides *. The xylem-strands are usually eccentrically mesarch. In *C. Saturni*, so far as I have observed, there is no continuous primary ring, the xylem-strands being isolated; medullary tracheides are either quite absent or extremely reduced; the strands are centrally mesarch. In these respects *C. fascicularis* agrees with *C. Saturni*, but there is the important difference that in the former the xylem-strands, in the lower part of their course, tend towards an endarch structure and diminish in size, while the secondary wood assumes a more Cordaitean character. Lastly, in *C. Beinertiana* the change has gone further, for while the outgoing xylem-strands are identical with those of *C. fascicularis* and *C. Saturni*, they attain, as they pass downwards in the pith, a completely endarch structure, the centripetal xylem here dying out.

* Certainly in *C. americana*, probably in *C. annularis*.

So far as the primary structure is concerned, the relationship throughout the series appears perfectly clear. It would of course be desirable to put it on a broader basis, in particular as regards the course of the leaf-traces, but data are almost lacking in the case of the "*Eristophyton*" species. All we know is that in *C. fascicularis*, at any rate, the protoxylem of the leaf-trace divided into two in passing through the zone of thickening, just as in *C. Saturni*, an indication of the subsequent division of the trace itself. But corticated specimens are needed before the affinities can be fully cleared up.

In the meantime, on the evidence already available, it seems to me clear that the species placed by Dr. Zalessky in *Eristophyton* are more nearly allied to the *Calamopitys* of Unger than to any other known plants, and that the affinity is closest between *C. fascicularis* and *C. Saturni*, while *C. annularis* and *americana* show a more primitive type of structure ; *C. Beinertiana*, on the other hand, is the most advanced of all the five species.

Affinities of the Genus.

Assuming that the five species which I have included under *Calamopitys* form a natural series of nearly allied plants, we may now consider the affinities of the group to other families. We have to compare our plants on the one hand with the Cycadofilices and on the other with the Palæozoic Gymnosperms.

Among the Cycadofilices * the nearest affinity would appear to be with the Lyginopterideæ. The comparison has hitherto been made with *Lyginopteris*, which, in its ring of mesarch xylem-strands and in the first division of the leaf-trace, presents considerable analogies with *Calamopitys Saturni*. The discovery that certain species of *Calamopitys* (*C. americana* and probably *C. annularis*) were protostelic suggests a relation to *Heterangium*, while the recent observation that several species of *Heterangium* contained a number of vascular bundles in the petiole (Scott, 1917) strengthens the analogy, and tends to remove the most obvious discrepancy between the structure of *Calamopitys* and that of Lyginopterideæ. At the same time it is clear that no direct filiation of the two groups is admissible ; *Calamopitys* is at least as ancient as the Heterangiums, and much more ancient than the polydesmic species : there is at no point any evidence of a transition from one group to the other ; they form parallel series, which, however, may well have had a common origin. The Medulloseæ are more remote, recalling *Calamopitys* only in their highly polydesmic petioles ; they show, however, a certain relation to Lyginopterideæ through *Heterangium*, and all three groups may probably have sprung from a common source.

* I use this name in a wide sense, to cover all plants which appear to be intermediate between Ferns and Cycadophyta whether their fructification is known or not.

No other Cycadofilices seem to approach *Calamopitys* at all nearly. There is a faint analogy in one point between the "*Eristophyton*" species of *Calamopitys* and *Protopitys*; in the latter the leaf-trace strands at the edge of the pith have a mesarch structure, with the protoxylem very near the inner surface; traced downwards there seems to be a transition to actual endarchy; there is thus some analogy with the lower part of the xylem-strands in *C. Beinertiana* and *C. fascicularis*, but in all other respects the structure is totally different (Solms-Laubach, 1893). With *Stenomyelon*, which has exarch or nearly exarch xylem-strands, there is nothing in common beyond the polydesmy of the petiole (Kidston & Gwynne-Vaughan, 1912).

It has been pointed out that the *Calamopitys* series appears to lead in the direction of Cordaitales, as shown, not only in the structure of the secondary wood in the "*Eristophyton*" species, but in the tendency to a dying out of the centripetal xylem, shown in the lower part of the course of the leaf-traces in those species. We may now enquire how far this advance went, and what was the particular direction which it took.

I am inclined to think that the advance towards a Cordaitalean type of organization did not after all go very far. I am chiefly influenced by the great size of the primary xylem-strand which constitutes the leaf-trace in *C. fascicularis* and *Beinertiana*, especially the former*. There are few plants even among the Cycadofilices in which the primary wood of the outgoing leaf-trace bears so large a proportion to the size of the stele, as in *C. fascicularis*†. It is almost a Filicinean character, and suggests that the leaf which such a trace supplied must have been large and very probably fern-like. This is certainly a strong argument for *C. fascicularis*, at all events, having still been one of the Cycadofilices. The case is less striking in *C. Beinertiana*, where the stele is so much larger in proportion, but these two species are admittedly nearly allied, and what is true of the one must in essentials be true of the other, though in *C. Beinertiana* the leaves may probably have been smaller in proportion to the stem.

For these reasons I should regard the whole series of species here included under *Calamopitys* as having belonged to Cycadofilices, in spite of the anatomical advance shown by *C. fascicularis* and *Beinertiana*. We may still ask whether these species show an approach to any special family among the Cordaitales, as at present known to us.

* Scott, 1902, Pl. 3. fig. 1.

† There is a physiological difficulty involved in the large size of the outgoing leaf-trace. As it dwindled rapidly in the downward direction, how was an adequate water-supply maintained? Possibly the solution is to be found, in the case of *C. fascicularis*, in the presence of the short wide tracheides of the inner layers of the secondary wood (Scott, 1902, p. 339; Pl. 3. fig. 3). These layers are in immediate contact with the outgoing leaf-traces, and appear to be adapted to the storage of water. They may have accumulated a supply on which the leaf-trace was able to draw. The storage-layers are the innermost of the secondary wood, and may well have been differentiated at a time when the bundles supplying the leaves were still actively functional.

There are no doubt some points in common with the Pityeæ, notably the centrally mesarch primary xylem-strands. In the genus *Pitys* most of the strands are embedded in the pith, as is also the case to a lesser extent in *C. fascicularis* and more rarely in *C. Saturni*. On the other hand *Archæopitys*, where the xylem-strands are distributed all over the pith †, goes much beyond anything that we find in *Calamopitys*, for there is no homology between those independent xylem-strands and the medullary metaxylem-tracheides occurring in the protostelic species of *Calamopitys* (Scott & Jeffrey, 1914, pp. 345, 365). The secondary wood of the Pityeæ usually has broad medullary rays; it is only in *Callixylon* (the most ancient genus of the family) that uniseriate rays prevail. The xylem-strands of Pityeæ are on a small scale compared with those of *Calamopitys*; the presumption is that the leaves which they supplied were likewise relatively small, as Dr. Gordon has now proved (Seward, Fossil Pl. iii.).

The two families are roughly contemporary; there are interesting analogies between them, but they can hardly be on the same line of descent.

The Poroxyleæ are a much later group (Permo-carboniferous). The stem-structure recalls that of *Lyginopteris*, but the primary xylem-strands are exarch, and the two strands of the double leaf-trace pass down at the margin of the pith through several internodes before they unite. The centripetal xylem dies out below, a point of resemblance to *Calamopitys Beinertiana*. The secondary wood is of the *Lyginopteris* type. The leaves were large and simple, showing a general similarity to those of Cordaiteæ. There is little to connect the family with *Calamopitys*, though a certain affinity, through Lyginopterideæ, may be presumed.

The structure of the secondary wood in the more advanced species of *Calamopitys* (*Eristophyton*) suggests a relation to the family Cordaiteæ; we now know that certain members of this family retained the centripetal wood of the xylem-strands in the stem (Scott & Maslen, 1910; Maslen, 1911; Scott, 1912, 1918). In *Mesoxylon* no primary centrifugal wood can be distinguished; the strands are exarch, as in *Poroxylon*. The leaf-trace here also is double, the two strands uniting on entering the pith or lower down, according to the species. *Parapitys Spenceri*, which I should also place in Cordaiteæ, is interesting, because here the primary xylem-strands, though very small, are distinctly mesarch (Scott, 1902, p. 358). No doubt all the Cordaiteæ are far removed from *Calamopitys*, but it is not impossible that they may represent an advanced stage of the same, or at least a similar, line of descent.

Zalessky's two genera *Cœnoxylon* (1911*) and *Mesopitys* (1911), both probably of Permian age, in which there are well-marked *endarch* strands of primary xylem, may also have some affinity with *Calamopitys*; as the author points out, this is especially probable in the case of *Mesopitys*, in

† Dr. Gordon has found a similar arrangement in *Pitys*. Seward, 1917, p. 288.

which he traces a certain resemblance to *Calamopitys* (*Eristophyton*) *Beinertiana*. The two genera in question seem to me to come nearest to the family Cordaiteæ, but to belong to a somewhat different branch from that which includes *Mesoxylon* and *Cordaites*.

The conclusion then, to which our comparisons appear to lead, is that while the genus *Calamopitys*, in the wide sense, belongs as a whole to the group Cycadofilices, in the neighbourhood of the Lyginopterideæ, its more advanced species, forming Dr. Zalessky's genus *Eristophyton*, show some approach in certain characters towards the class Cordaitales, and especially the family Cordaiteæ.

Summary.

In the first part of the paper additional evidence is brought forward as to the course of the leaf-trace in *Calamopitys americana*. The trace, after separating from the reparatory strand, divides into two in traversing the zone of secondary wood. It thus differs from the trace of *C. Saturni*, in which division is only completed beyond the zone of thickening.

The second part of the paper is devoted to a re-examination of the five species.

In *C. annularis* the zone of primary xylem is almost if not quite continuous. The primary xylem-strands are, as a rule, eccentrically mesarch, the protoxylem lying nearer the outer side of the strand. Tubular elements, which are probably medullary tracheides, are present in the pith, indicating a protostelic structure.

Each leaf-trace strand, on its exit from the wood, is surrounded by its own zone of secondary xylem.

In all these points *C. annularis* agrees with *C. americana*.

In the Halle specimen, a small branch referred by Solms-Laubach to *C. annularis*, the medullary rays are narrow, resembling those of *C. fascicularis* and *C. Beinertiana*.

In *C. Saturni* the primary xylem-strands are found to be completely isolated ; there is no continuous xylem-ring.

The xylem-strands are, as a rule, centrally mesarch, with the centrifugal and centripetal portions equally developed. There is little or no indication of medullary tracheides.

The three species, *C. americana*, *C. annularis*, and *C. Saturni*, all had *Kalymma* petioles of very similar structure.

In *C. fascicularis* the leaf-trace strands at their exit from the small pith are of large size, centrally mesarch and perfectly similar to those of *C. Saturni*. Lower down in their course they diminish in size and the centripetal portion of the xylem becomes much reduced. The protoxylem of the leaf-trace divides into two in passing through the zone of secondary wood.

The wood has narrow medullary rays and is generally of a Cordaitean type. Its inner layers consist of short, wide tracheides, suggesting a water-storing function.

In *C. Beinertiana* the pith is large and contains sclerotic nests. The xylem-strands are similar to those of the preceding species, except that in the lower part of their course they become actually endarch. Division of the protoxylem has not been observed. The wood has a Cordaitean character.

A synopsis of the five species is given on p. 221.

The affinities of the species are then considered, with reference to Dr. Zalessky's proposed separation of *C. fascicularis* and *C. Beinertiana* under the generic name *Eristophyton*; the conclusion is reached that, while generic separation may ultimately be justified, all the five species form a natural series, in which *C. Saturni* occupies, in certain respects, an intermediate position, between *C. annularis* and *C. americana* on the one hand, and *C. fascicularis* and *C. Beinertiana* on the other.

Lastly, the affinities of the genus are discussed. While the whole *Calamopitys* series should remain in Cycadofilices, the nearest affinity being with the Lyginopterideæ, through *Heterangium*, the species *C. fascicularis* and *C. Beinertiana* show some advance towards the structure of Cordaitales and especially of the family Cordaiteæ.

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EXPLANATION OF THE PLATES.

All the figures are photographic and frequently need to be examined with a lens.

PLATE 6.

Calamopitys americana.

(From photographs by Mr. W. Tams.)

Series, from below upwards, to show division of the leaf-trace. All the figures (except 2 and 4) are × about 7.

Fig. 1. Part of stele, with much secondary wood. The single trace (*l.t.*) is at the margin of the pith. Section 1 (S. 2944).

2. Primary xylem-strand of leaf-trace with adjacent secondary wood from same section. *px.*, the partly disorganized protoxylem of the strand. × 37.

3. Two sections higher up. *l.t.*, leaf-trace; *r.*, reparatory strand. Section 3 (S. 2946).

4. Leaf-trace, reparatory strand and adjacent tissues from same section, more magnified. *px.*, protoxylem of leaf-trace; *px.r.*, that of reparatory strand, through which a crack passes. × 18.

5. Two sections above the last. The leaf-trace (*l.t.*) shows signs of division, but is still slightly connected with the reparatory strand, *r.* Section 5 (S. 2948).

6. Four sections above the last. The leaf-trace (*l.t.*) is evidently dividing into two. Section 9 (S. 2952).

7. Four sections above the last. The leaf-trace has now divided into two (*l.t.*, *l.t.*). The reparatory strand (*r.*) is still seen behind the trace. Section 13 (S. 2956).

8. Two sections above the last. The two strands of the leaf-trace (*l.t*, *l.t.*) are now widely separated, with secondary wood between them, and the whole has moved considerably further out. Section 15 (S. 2958).

9. Two sections above the last. The two leaf-trace strands (*l.t.*, *l.t.*) have moved further apart and each has its own separate fan of secondary wood. The cortex is well shown on the left. Section 17 (S. 2960).

10. Three sections above the last. The two leaf-trace strands (*l.t.*, *l.t.*) are now passing beyond the wood of the stele. Each is almost or quite surrounded by its own zone of secondary wood. Section 20 (S. 2963).

PLATE 7.

Calamopitys annularis.

From photographs (except 14 & 17) by Mr. W. Tams. 14 & 17 by Mr. L. A. Boodle, F.L.S.

Fig. 11. General section of stele, with part of cortex and leaf-base, containing three bundles (*v.b.*) attached on the left. × 2¼. Section 40 *a* (Coll. Solms 413).

12. Stele, from an adjacent section of the same specimen. *l.t.*, probable position of a leaf-trace. × 3. Section 97, Berlin.

13. Part of primary and secondary wood, from the same section as Phot. 11. *l.t.*, probable primary xylem-strand of a leaf-trace. A reparatory strand lies just behind. *px.*, protoxylem of one of the eccentrically mesarch xylem-strands of the

stele. The primary wood is nearly continuous. × about 25. Section 40*a* (Coll. Solms 413).

Fig. 14. Double xylem-strand from the same section as Phot. 12. *px., px.*, the two protoxylem-groups of the strand, which appears to be separated a little from the secondary wood above. × about 30. Section 97, Berlin.

15. Radial section through the pith of the same specimen. The longitudinal axis is horizontal. *t. t. t.'*, tubes, probably medullary tracheides. × about 16. Section 97R, Berlin (Coll. Solms 413).

16. Shows one of the tubes (*t.'*) in the pith, more magnified. × 38.

17. A vascular bundle and surrounding tissue from the leaf-base of the same specimen. There appear to be three protoxylem-groups (*px.*). × 35. Section 97, Berlin.

18. General transverse section of another specimen, with a portion of leaf-base, containing two bundles (*v.b.*), on the left. *l.t.*, leaf-trace strand shown in detail in Text-fig., p. 212. × 1¾. Section 98, Berlin (Coll. Solms 411).

19. General transverse section of the Halle specimen, showing the dense wood, and, on the right, the small pith (*p.*). × 3½. Section 761, Halle (Coll. Solms 420).

20. Pith, with primary and part of secondary wood from the same section, more magnified. The primary wood is almost continuous and there appear to be medullary tracheides. *px.*, a protoxylem-group; *m.r.*, one of the uniseriate rays of the secondary wood. × about 25.

PLATE 8.

Calamopitys Saturni.

(From photographs by Mr. W. Tams.)

Fig. 21. General transverse section, showing the small pith and primary wood, the broad secondary wood with medullary rays dilated outwards, and the remains of the phloem (*ph.*). × 13. Section 76, Berlin (Coll. Solms 422).

22. Pith and primary wood more magnified. The six distinct xylem-strands round the pith and the leaf-trace are seen. *px.l.t*, protoxylem of leaf-trace; *px.r.*, protoxylem of reparatory strand behind it. *x.*, a xylem-strand which appears to be somewhat embedded in the pith. × about 50.

Calamopitys fascicularis.

23. Leaf-trace in a tangential section of the wood, showing the two widely separated protoxylem-groups, *px, px.* × 46. (Mr. W. Tams.) Section S. 2474.

Calamopitys Beinertiana.

24. Part of transverse section, showing a large mesarch xylem-strand leaving the pith and entering the secondary wood. *px.*, protoxylem of strand. × 23. From a section of Count Solms-Laubach's Falkenberg specimen.

25. From the same section, showing a xylem-strand lower down in its course, smaller, but still mesarch. *px.*, its protoxylem. × about 65.

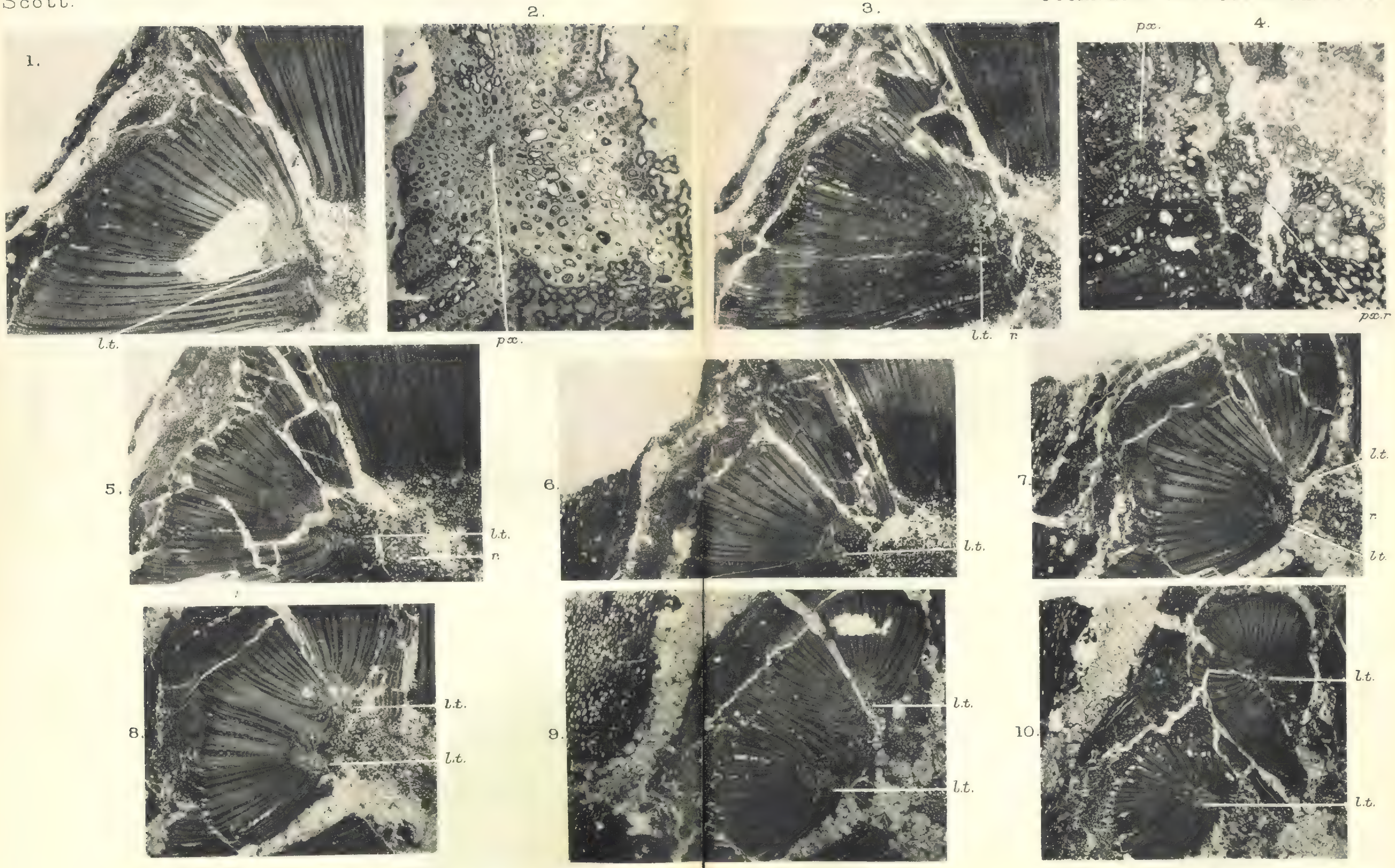
26. Another xylem-strand, cut still lower down, very small and endarch. *px.*, its protoxylem. × 65.

The above photographs, 24–26, by Mr. L. A. Boodle, F.L.S.

27. General transverse section of a Norham Bridge specimen. Numerous sclerotic nests in the large pith. *l.t.–l.t.*, the three leaf-traces passing through the wood. × about 2½. From a section (No. 1) lent by Dr. Gordon.

28. Leaf-trace in a tangential section of the wood, from the same specimen. There appears to be one median protoxylem. × about 48. From a section (No. 4) lent by Dr. Kidston, F.R.S.

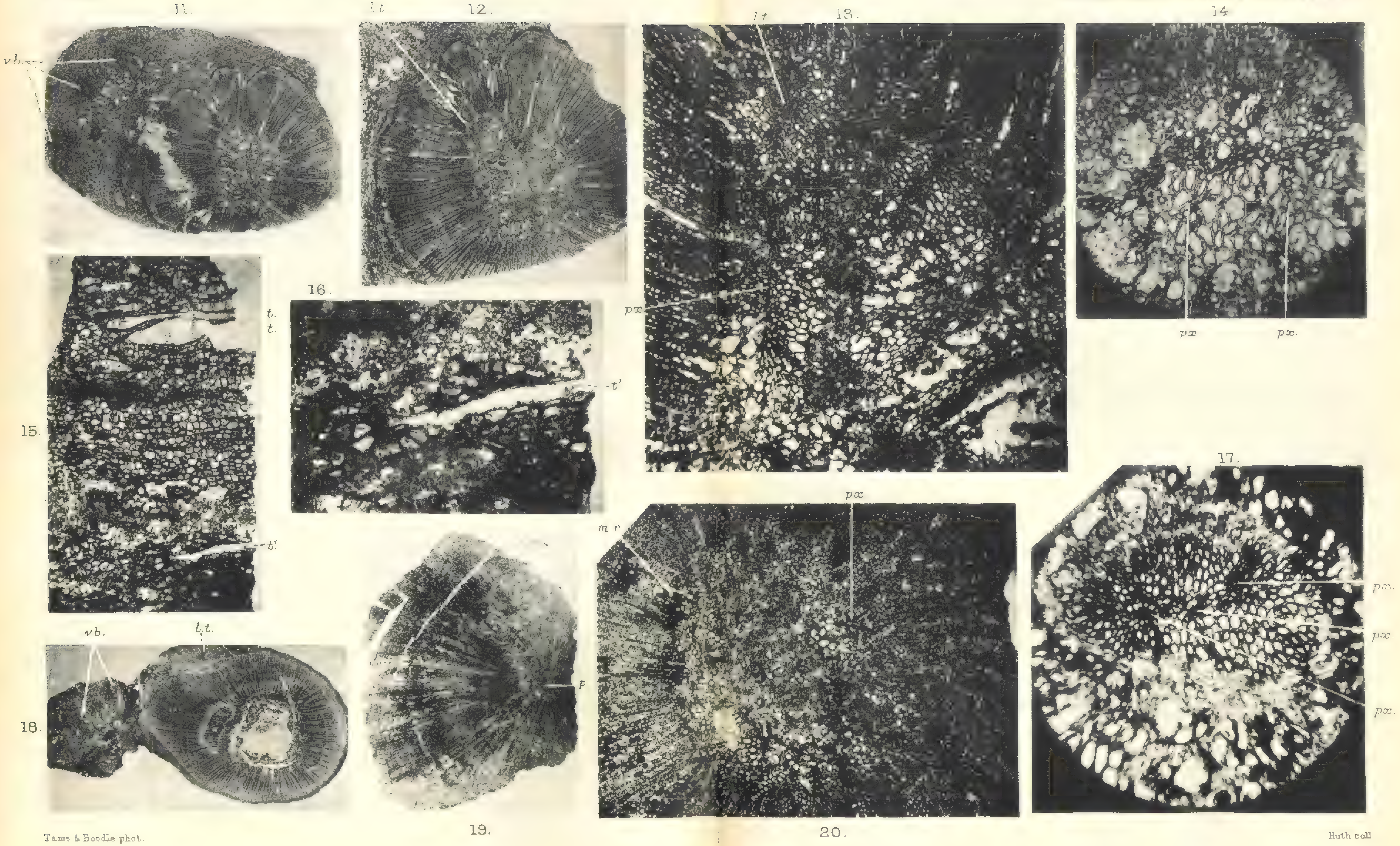
Phots. 27 & 28 by Mr. W. Tams.



Tams phot

Huth coll.

CALAMOPITYS AMERICANA.



Tams & Boodle phot.

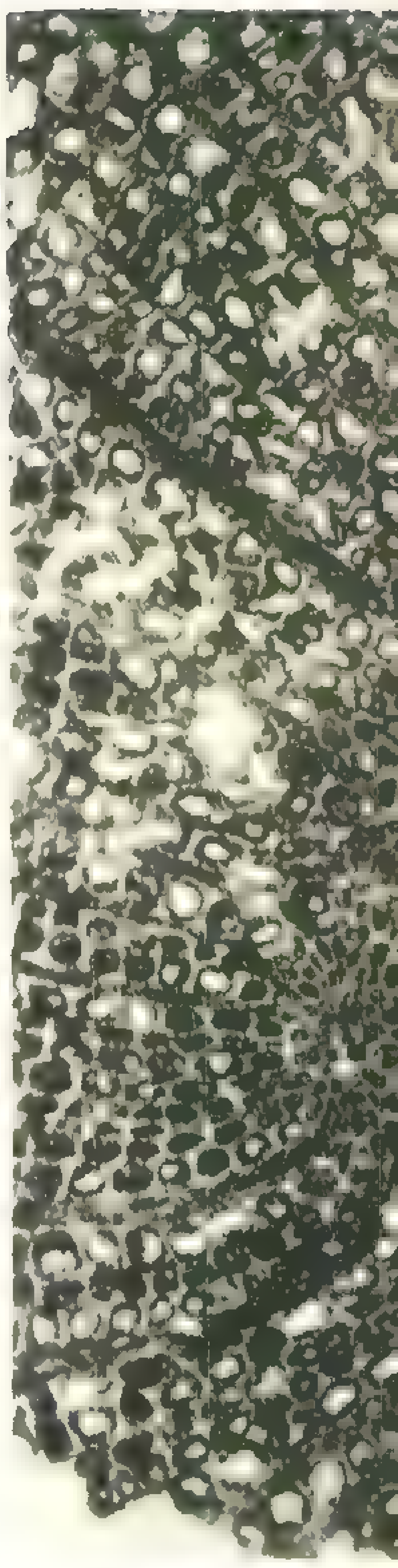
Huth coll

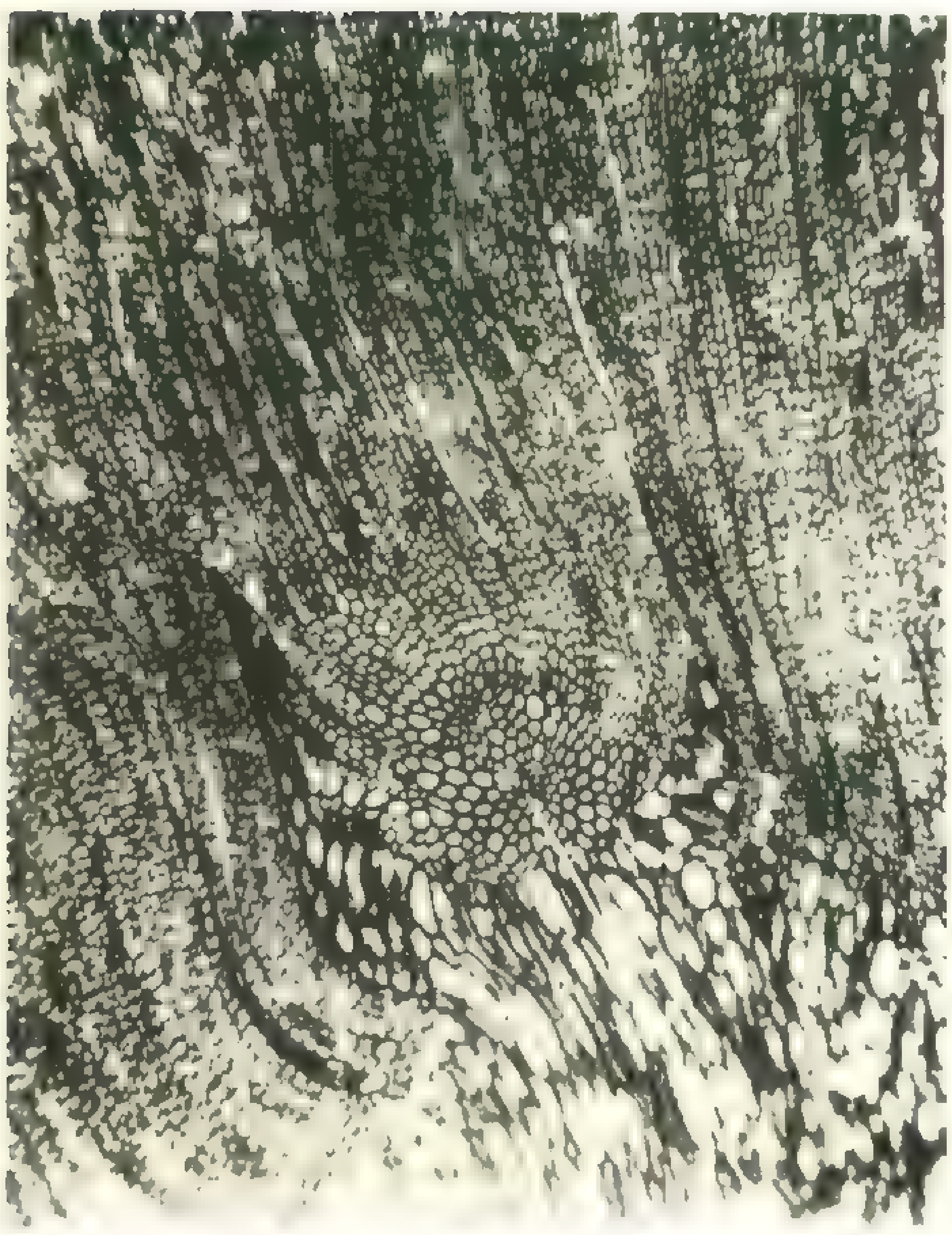
CALAMOPITYS ANNULARIS.

Scott.

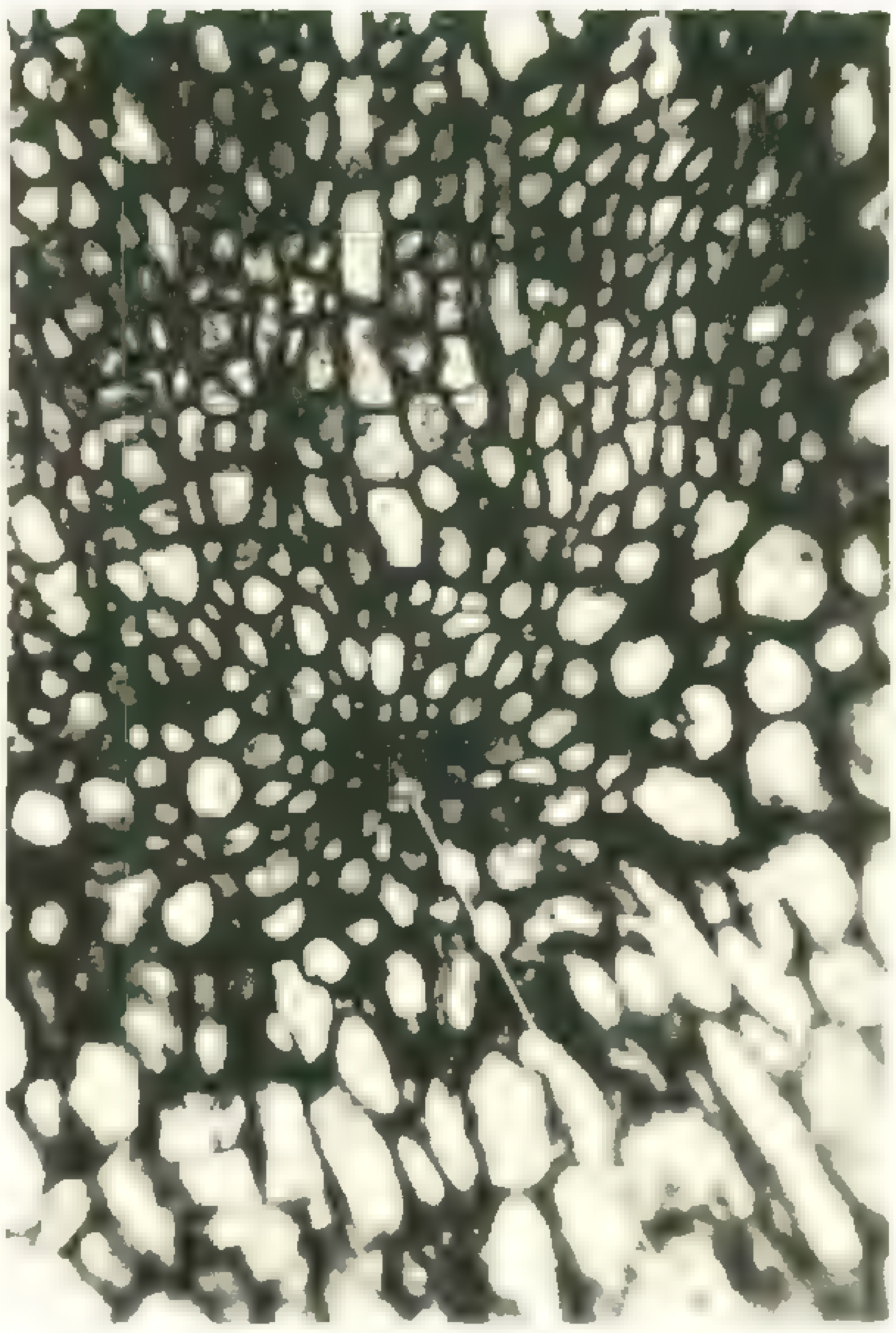
21.

ph

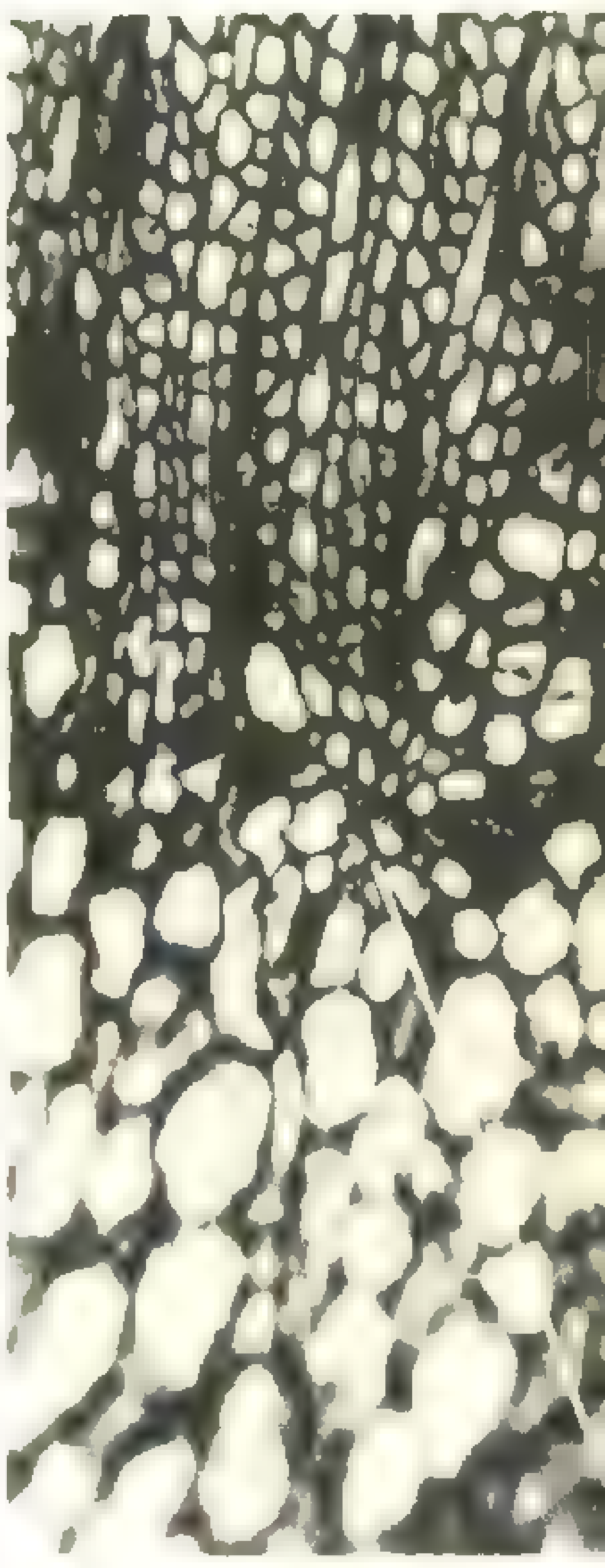




24. *px.*



25. *px.*



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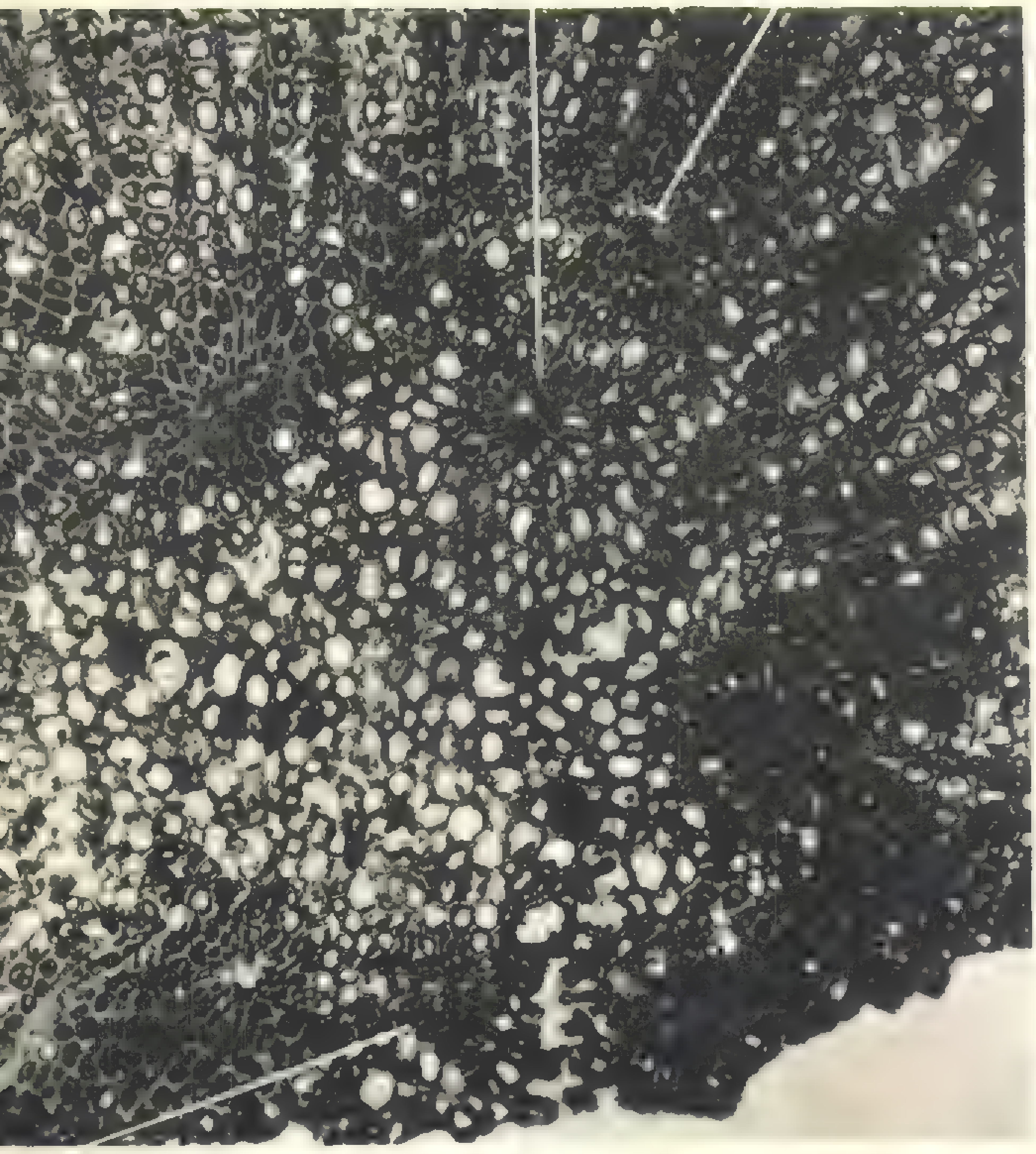
21, 22. CALAMOPITYS SATURNI, 23

22.



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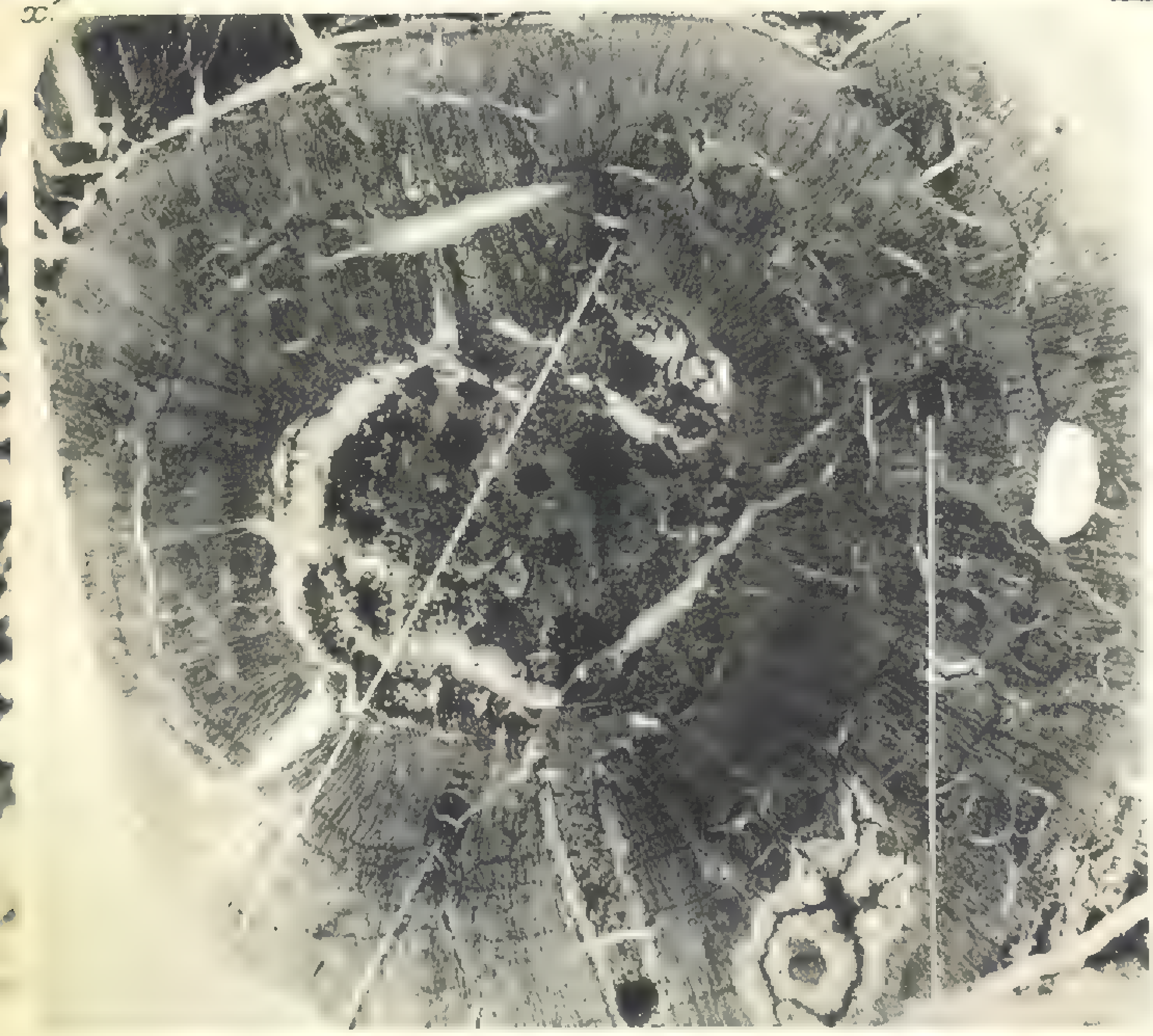

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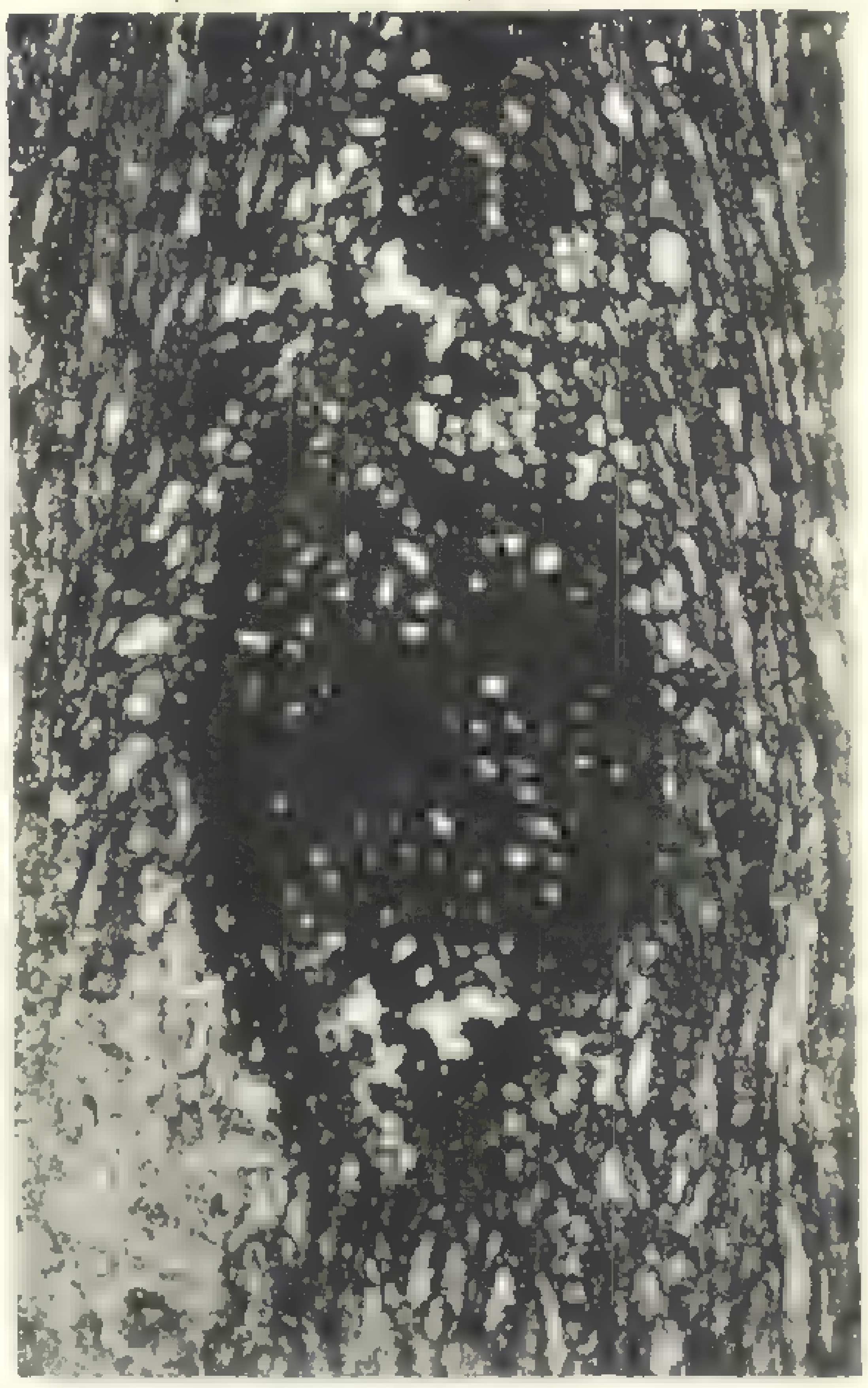

28.

Huth coll.

ASCICULARIS, 24-28. C. BEINERTIANA.

A Revision of the Genera *Fumaria* and *Rupicapnos*. By Herbert William Pugsley, B.A. (Communicated by A. B. Rendle, D.Sc. (Lond.), F.R.S., Sec.L.S.)

(Plates 9–16.)

[Read 3rd May, 1917.]

Introduction.

In the course of writing "The Genus *Fumaria* in Britain," published as Supplement I to the 'Journal of Botany' for 1912, it was found necessary to examine not only those Foreign Fumitories that were most closely connected with the British forms, but in a general way all the annual species of the genus of which material could be obtained; and remarks on the salient features of various non-British species are embodied in that work in the reviews of the generic subdivisions.

During the winter of 1912–13 several Foreign collections were received for examination, notably the fine sets of Mr. Charles Bailey and of Zürich University, the latter kindly sent by Professor Schinz; and with this material for reference (numbering over 2000 sheets), in addition to the herbaria at the British Museum and at Kew, where some important types are preserved, an opportunity presented itself to effect an appreciable advance in the study of the genus. About the same time valuable supplies of living plants were obtained from the Riviera and the neighbourhood of Gibraltar through the kindness of Mr. H. Stuart Thompson, Major A. H. Wolley-Dod, and Mr. E. G. Baker, and an opportunity was taken during the succeeding summer to visit the Boissier Herbarium at Geneva and examine the important types there.

The result of this work is the present paper, the completion of which has been seriously delayed owing to the pressure of other duties consequent upon the war. An attempt is now made to offer a general criticism of all the species of the genus, which it is thought may be useful for reference as a Supplement to the Latin edition of Olof Hammar's "Monographia Generis Fumariarum" (Nov. Act. Reg. Soc. Scient. Upsal. ser. 3. ii. fasc. post. p. 258), published at Upsala in 1857, taken in conjunction with C. Haussknecht's "Beitrag zur Kentniss der Arten von *Fumaria*, sect. *Sphærocapnos*," in 'Flora,' lvi. (new series xxxi.) (1873), the writer's above-mentioned "Genus *Fumaria* in Britain," and certain other works wherein the *Fumariæ* are dealt with in more or less detail. Hammar's earlier Monograph ("En Monografi öfver Slägtet *Fumaria*"), which was published at Lund in 1854 and considerably amended in his later work, is referred to only in a few special cases.

Classification of the Genus *Fumaria*.

In this Revision *F. spicata*, Linn. and its allies are omitted as they seem best referred to a separate genus *Platycapnos*, Bernhardi in 'Linnæa,' viii. 471 (1833); and *Discocapnos*, Cham. & Schlecht. in 'Linnæa,' i. 569 (1826), is similarly excluded.

The genus *Fumaria*, thus restricted, has been commonly regarded as comprising two sections, viz.:—(1) *Petrocapnos*, Cosson & Durieu in Bull. Soc. Bot. France, ii. 305 (1855), et Cosson, Comp. Fl. Atlant. ii. 80 (1883–1887); (=*Rupicapnos*, Pomel, Mat. Fl. Atlant. 16 (1860), et Nouv. Mat. Fl. Atlant. i. 240 (1874), as a genus); in which the species are usually perennial, nearly stemless, with leaves mostly radical, a subcorymbose inflorescence, and strongly tubercular-rugose fruits: and (2) *Sphærocapnos*, DC. Syst. Nat. Veg. ii. 131 (1821); Cosson, Comp. Fl. Atlant. ii. 83 (1883–1887); consisting of the annual species, with elongate stems, cauline leaves, racemose flowers, and generally less tubercular fruits.

It was at first intended that this paper should deal only with the second of these sections, as indicated in the notice read before the Society on the 3rd May, 1917; but subsequently, on the expressed wish of the Council, an extension was decided upon in order to complete a review of the whole genus. An examination of the species of *Petrocapnos*, however, revealed that in addition to the points of distinction noted by Cosson and Pomel, there are other important floral and fruiting characters by which they may be separated as a group from the annual *Fumariæ*, and it is consequently felt essential to follow Pomel in treating them as a distinct genus. An account of these plants follows that of the true Fumitories.

With this view the genus *Fumaria* becomes synonymous with the section *Sphærocapnos*, DC., and the classification followed is that already adopted for the British species, coinciding practically with that of Haussknecht's Revision in 'Flora,' lvi. (1873), with an emendation of the sequence of the subdivisions. It is only after considerable hesitation that this system has been preferred to that of the more finished Monograph of Hammar, and it is readily admitted that Haussknecht's two primary divisions of *Latisectæ* and *Angustisectæ* are unsatisfactory until their definitions are enlarged by the addition of floral characters and they become converted into *Grandiflora* and *Parviflora* respectively. A third classification, relying on the curvature of the fruiting pedicel or its absence as a primary basis of segregation, which was adopted by Boissier in the 'Flora Orientalis' owing to the ready obliteration of the corolla-characters in exsiccata, seems unreliable owing to the inconstancy of the recurved pedicel in the species in which it is commonly seen, and unnatural in its association of plants sometimes widely divergent in other characters.

It will be remembered that Hammar was led to write his Monograph from

seeing Fries' fine series of cultivated Fumitories at Upsala, and as a large proportion of his descriptions are taken from plants subsequently grown at Lund, he was evidently well acquainted with many of the living forms and his choice of the corolla-characters as the basis of generic sections cannot be lightly set aside. But, on the whole, the annual *Fumariæ* seem to fall naturally into two rather than three large groups. So far as the small-flowered species are concerned there is no real discrepancy between Hammar's arrangement and that of Haussknecht, for the *Officinales* and the *Angustisectæ* comprise practically the same species, one author relying on the floral features and the other on those of the foliage with which they are commonly associated. But while Hammar's sectional definitions of his *Officinales*, and also of his *Agrariæ*, fairly cover all the species placed under them (although in the former the margins of the upper petal are not often truly patent), it is not so with his third section, *Capreolatæ*, which show marked variations in the corolla. As instances of this, the spreading margins of the lower petal in *F. Bastardii*, Bor. (*F. media β. confusa*, Hamm.) may be cited, or the normally obtuse upper petal of *F. Gussonei*, Boiss. (Pl. 9, figs. 1–3). And when more recently discovered plants are included, a complete series of transitional forms may be traced through this section, connecting *F. capreolata*, Linn., to which Hammar's sectional diagnosis of the corolla correctly applies, with the species of the section *Agrariæ*. At the same time, neither the *Agrariæ* nor the *Capreolatæ* can be said to be similarly connected with the *Officinales*.

It may thus be argued, if the floral characters alone are considered, that the plants placed by Hammar in his section *Capreolatæ* differ from the *Agrariæ* in that the development of the margins of their outer petals is more or less arrested. In some other important features, such as size of flower and character of foliage, most of the *Capreolatæ* approximate to the *Agrarian* species and are plainly different from the *Officinales* or *Parvifloræ*. The fruiting characters cannot be similarly contrasted, for while a certain degree of uniformity prevails among the fruits of the *Agrariæ*, which are usually large and coarsely rugose, and also to a less extent among the *Officinales*, where they are very rarely large, coarsely rugose, or yet quite smooth, in the *Capreolatæ* of Hammar this organ is eminently variable, being in some species quite small and perfectly smooth, in others larger than in some Agrarian species or distinctly rugose. As the variations of the fruit in Hammar's *Capreolatæ*, therefore, give little indication of any group-affinity, it seems safest to rely chiefly on the foliage and the flowers, and to regard the section as related to the *Agrariæ* rather than a distinct group equal in rank to these and the *Officinales* or *Parvifloræ*.

The contention for two natural groups—*Grandiflora* or *Latisectæ* and *Parviflora* or *Angustisectæ*—is further supported by the geographical distribution of the species. The *Agrariæ*, especially *F. agraria* and

F. rupestris, bear a superficial resemblance in flower and fruit to the perennial *F. africana*, Lamk., of the section *Petrocapnos*, which Hammar, who probably had very scanty material before him, included among them. Like *F. africana* they are lovers of warmth, and some of them grow in native habitats on rocks in North Africa, whence they appear to have spread to cultivated land. Most of them flourish in North Africa, and while they extend round nearly the whole Mediterranean littoral, they are absent at any great altitude or distance from the sea. Away from the Mediterranean *F. agraria* alone spreads through Portugal, where rigorous winters are unknown, while *F. occidentalis* curiously occurs as an isolated outlier of the group in West Cornwall, where the mildness of the winters, considering the latitude, is proverbial.

The other large-flowered Fumitories, Hammar's *Capreolatæ*, are likewise most abundant round the Mediterranean, especially towards the west, whence they extend over the islands of the North Atlantic. They also range through France and Britain, but are rare or absent east and north of a line drawn southwards along the Rhine and across the Eastern Alps and Balkans to the Black Sea. Their distribution thus agrees generally with that of the *Agrariæ*, but is less restricted to the south, the *Capreolatæ* forms being evidently less impatient of cold and able to maintain themselves about as far northwards as the isotherm of 32° F. for the month of January.

The large-flowered Fumitories, regarded as a whole, may thus be considered as primarily plants of the Mediterranean region, extending northwards in Western Europe, but practically absent from Central and Eastern Europe, and from Asia except in the vicinity of the Mediterranean. It is evident that they cannot exist where the winter climate is severe.

On the other hand, the *Parviflorœ* or *Officinales* of Hammar have a different and much wider distribution and are very much hardier. While they inhabit almost the whole region occupied by the *Grandifloræ*, they occur in the greatest abundance and variety in Eastern Europe, and in Western and Central Asia, where they extend as far as India and Mongolia. In some of their habitats they maintain an existence under climatic conditions very severe for annuals. *F. Schleicheri* and *F. Vaillantii* are found in the Altai region, and both of these species grow at an altitude of nearly 2000 m. in the Swiss Alps. Four species, *F. parviflora*, *F. Vaillantii*, *F. Schrammii*, and *F. officinalis*, have a remarkably wide distribution, ranging from the Atlantic far into Asia; but most of the local species are Asiatic, although some rare outliers are found in the high mountains of Africa. It will thus be seen that the small-flowered Fumitories are plants of almost the whole Palæarctic region outside the Arctic Circle and excluding China, with a tendency to predominate towards the east and with isolated species on certain African mountains.

From these considerations, morphological and geographical, it has been decided to follow Haussknecht in dividing the genus into two Sections, *Latisectæ* or *Grandiflora*, and *Angustisectæ* or *Parviflora*, based mainly on a combination of foliar and floral characters, as has been done in "*Fumaria* in Britain."

The Section *Grandiflora*, representing the *Agrariæ* and *Capreolatæ* of Hammar, is readily subdivided into three subsections, as is done by Haussknecht, by eliminating, as *Murales*, from the well-marked Agrarian and Capreolate species the more dubious and intermediate plants, some of which present distinct individual features, while one or two others show affinities with certain of the *Parvifloræ*.

Of the Section *Parviflora* (*Officinales* of Hammar) the most strongly marked species are *F. parviflora*, Lam. and its allies, which were distinguished in "*Fumaria* in Britain" as *Microsepalæ* from their very small sepals. Among the other species, *F. officinalis* with some allied forms seems to constitute a natural subsection (*Officinales*) owing to the peculiarly shaped and broad fruits, as well as the larger flowers with less minute sepals. The remaining species—all well-marked by relatively large sepals—fall into a homogeneous subsection *Latisepalæ*. In these plants the form of the corolla is less characteristic than in the other *Parvifloræ*, and some of them show affinities with a few species of the *Murales*.

With regard to the generic sequence of these subdivisions, the most natural arrangement appears to be a commencement with the subsection *Agrariæ*, followed by the *Capreolatæ* and the *Murales* respectively. As the *Murales* show affinities with the *Latisepalæ* these subsections are placed in juxtaposition, and after them the *Officinales*, with the *Microsepalæ*, comprising the most extreme small-flowered forms, completing the genus.

Species of *Fumaria* and their Distribution.

The number of species of *Fumaria* recognized in this Revision is 46—27 *Grandifloræ* and 19 *Parvifloræ*. Hammar's number of species in his final monograph is 24, including *F. Heldreichii* but without *F. corymbosa*; and Haussknecht gives 35, if *F. microstachys* and *F. microcarpa* are included. Twenty of Hammar's species are retained, three of the remainder, *F. affinis*, *F. vagans*, and *F. Gussonei*, being united with *F. media β. confusa* as one species *F. Bastardii*, and *F. Heldreichii* is reduced to a variety of *F. Thuretii*.

Of Haussknecht's species *F. gaditana* and *F. Pikermiana* are made varieties of *F. sepium* and *F. Thuretii* respectively, and *F. malacitana* is identified with *F. macrosepala*; the remaining 32 retain their specific rank excepting *F. Boræi*, which is reduced to a subspecies of *F. muralis*.

The 15 additional species are variously accounted for. *F. Gaillardotii* is segregated from the allied *F. major*, *F. apiculata* from *F. muralis*, and the Dalmatian *F. Petteri* from *F. Thuretii*. Haussknecht's varieties *F. capreolata*

β. intermedia, F. Vaillantii γ. indica, and *δ. Schrammii* are raised to specific rank as *F. dubia, F. indica*, and *F. Schrammii* respectively. The Canary Islands plant referred to *F. montana*, Schmidt, is separated as a distinct species *F. coccinea. F. bicolor, F. Martinii, F. purpurea*, and *F. occidentalis*, described since the publication of Haussknecht's work, are admitted as new species. Two Moroccan plants, ranked by John Ball as *F. agraria* var. *atlantica* and subspecies *tenuisecta*, are described as new species *F. berberica* and *F. Ballii. F. micrantha* var. *Parlatoriana*, Boiss. is included as *F. bracteosa*; and *F. australis* is distinguished for the first time.

The continental distribution of these 46 species may be summarized as follows:—

Of the *Grandifloræ*	21	occur in	Europe	and	7	are peculiar to	that continent.
	18	,,	Africa	,,	6	,,	,,
	5	,,	Asia	,,	0	,,	,,
Of the *Parvifloræ*	9	,,	Europe	,,	2	,,	,,
	9	,,	Africa	,,	4	,,	,,
	13	,,	Asia	,,	5	,,	,,

Of individual countries, the richest in Europe is Spain, where 17 species occur—11 *Grandifloræ* and 6 *Parvifloræ*: France has 12 species, 6 of each section; Britain 10, 6 *Grandifloræ* and 4 *Parvifloræ*; Italy 11, 7 *Grandifloræ* and 4 *Parvifloræ*; Balkan Peninsula 16, 9 *Grandifloræ* and 7 *Parvifloræ*; Germany 9, 2 *Grandifloræ* and 7 *Parvifloræ*; Russia 9, 1 *Grandiflora* (introduced ?) and 8 *Parvifloræ*. In Africa, 14 species (10 *Grandifloræ* and 4 *Parvifloræ*) grow in Algeria, and 8 (3 *Grandifloræ* and 5 *Parvifloræ*) in Egypt. The number for Asiatic Turkey is 16, viz.: 5 *Grandifloræ* and 11 *Parvifloræ*; and for Persia 5, all *Parvifloræ*. These figures indicate the predominance of the *Grandifloræ* in the Mediterranean region and Western Europe, and of the *Parvifloræ* towards the East and North, and in Asia, as pointed out on page 236.

While six species, *F. capreolata, F. micrantha, F. officinalis, F. Vaillantii, F. Schrammii*, and *F. parviflora*, are remarkable for their wide distribution, a considerable number of species are distinctly local. Some of these are endemic in insular habitats, such as *F. purpurea* and *F. occidentalis* in Britain, *F. coccinea* in the Canaries, and *F. montana* of the Cape Verde Islands. *F. bicolor*, of the islands of the Western Mediterranean, is almost a similar example, although it occurs also in Algeria. *F. Ballii, F. dubia, F. berberica*, and *F. Munbyi* all seem to be rare North African plants; *F. amarysia* and *F. Petteri* are confined to Greece and Dalmatia respectively; and among the *Parvifloræ, F. Jankæ* appears local in Hungary, *F. Boissieri* in Mesopotamia, *F. microstachys* in Egypt, and *F. australis* in East Africa. Three other scarce species, *F. rupestris, F. macrosepala*, and *F. sepium*, are notable as only occurring locally on both sides of the strait of Gibraltar; and *F. apiculata* and *F. Reuteri* seem sparingly distributed in the Iberian Peninsula.

It is probable that in the Old World the range of the more widely spread species has been extended through human agency, as has obviously happened in America, where *F. agraria* and *F. capreolata* are extensively naturalized in the southern continent and *F. parviflora* in Mexico. The remarkable distribution of *F. muralis* from Western Europe round Africa to the East Indies and New Zealand is clearly due to the same cause.

Nature of Habitats of the Fumariæ.

In north-western Europe, where the conditions of an open association and free soil such as the annual Fumitories require are now rarely to be met with in natural habitats owing to the spread of modern civilization, the plants of this genus are very generally found as weeds of cultivation ; and owing to the moist summers that usually prevail, they may commonly be seen from spring to autumn according to the tillage of the ground, for the frequent rains afford continuously a sufficient degree of moisture for the germination of their hard-coated seeds. In these regions they show considerable variation in different situations and as the season progresses, and the diverse forms that they assume have been carefully diagnosed by Haussknecht in the case of the small-flowered species with which he was familiar in Germany.

In the Mediterranean region, however, as well as in Asia, where the summers are normally hot, and dry rather than wet, it is only after the winter rains that the seeds are able to germinate, and consequently *Fumariæ* are generally flowers of spring or early summer only and are liable to less vegetative change.

In these southern and eastern countries it is evident from the notes of collectors that they are by no means confined to disturbed or cultivated ground, for the conditions of environment which they need frequently exist in nature on an extensive scale. The following records of apparently natural habitats have been noted :—Among the *Grandifloræ*, *F. rupestris* from rock fissures and calcareous rocks ; *F. atlantica* from shady rocks ; *F. flabellata* from grassy hills and maritime pastures ; *F. dubia* from "mountains" near Algiers ; *F. macrosepala* from shady rocks, rock-slopes and among *Chamærops* ; *F. coccinea* from moist rocks and mountain wood-edges ; *F. bicolor* from bushy places and slopes near the sea ; and *F. sepium* var. *gaditana* from stony slopes. Of the *Parvifloræ*, *F. montana* from mountain rocks ; *F. Kralikii* on rocks in the Crimea (Pallas) ; *F. officinalis* var. *minor* on rocks and in stony places in the Crimea (Pallas & Bieberstein) ; *F. Vaillantii* from sandy hills of the desert in Songaria ; *F. asepala* in stony, uncultivated places ; *F. parviflora* in the desert near Bagdad ; *F. parviflora* var. *latisecta* in shady places of Mt. Sinai ; and *F. parviflora* var. *persica* on maritime sands of the Caspian.

From this list it may not unreasonably be assumed that clearly native localities for a large proportion of the known species will someday be traced, although in some countries, such as Britain, where very great natural changes have taken place, this may no longer be possible, the original stations for the endemic species being now lost and the plants compelled to maintain themselves entirely on ground periodically disturbed by cultivation.

The prevalence of the *Grandifloræ* in the Old Red Sandstone districts of Great Britain, and of *F. Vaillantii* and *F. parviflora* on the Chalk was pointed out in "*Fumaria* in Britain," but it has not been found possible to determine the geological formations favoured by different species outside the British Islands.

The Genus *Rupicapnos*.

Of the plants treated by Cosson as a section *Petrocapnos* of *Fumaria* and by Pomel as a separate genus *Rupicapnos*, the earliest known is the large-flowered species discovered in Algeria by Desfontaines and described by Lamarck in 1788 as *Fumaria africana*. This fumitory was placed by De Candolle in Syst. Nat. Veg. ii. p. 132, with *Fumaria spicata*, L., to form a section *Platycapnos* of *Fumaria*, characterized by compressed fruits—an arrangement probably due to Desfontaines' description of the silicule as "comprimée" rather than to any actual knowledge of the plant.

In 1855 the section *Petrocapnos* was established by Cosson & Durieu in Bull. Soc. Bot. France, ii. p. 305, with four species, one of these being *F. africana*. The sectional diagnosis states that the group consists of rock-plants, mostly nearly stemless perennials, with long-petioled leaves exceeding the subcorymbose racemes of flowers, which are borne on very long pedicels, and with compressed, apiculate fruits. The resemblance of these plants to the genus *Sarcocapnos*, both in habit and in the flowers of one species, is duly noted.

Hammar, at the time of writing his Monograph of *Fumaria*, seems to have been unaware of this publication of the section *Petrocapnos*, and included the one species known to him, *F. africana*, in his section *Agrariæ*.

A more adequate account of these plants, though embracing only the four species already described, appeared in 1860 in a small pamphlet entitled "Matériaux pour la Flore Atlantique," by A. Pomel. In this work the genus *Rupicapnos* is established, and in addition to the characters of *Petrocapnos* noted by Cosson & Durieu, the prevalent gibbosity at the base of the lower petal is pointed out, as well as the curious elongation and reflexing of the fruiting pedicels whereby the seeds are carried down to the clefts of the rocks in which the plants grow. The wholly adherent endocarp of the fruit, also, is contrasted with the apically separated and depressed endocarp of *Fumaria*, and it is demonstrated that while the amphitropous seed of this latter genus shows a bowl-shaped hollow on the upper side, into which the depressed

endocarp of the fruit fits, in *Rupicapnos* the upper part of the seed is simply rounded without any hollow. The absence of the strongly marked fold in the albumen below the micropyle, as seen in *Fumaria*, is also noted.

In a second work fourteen years later (Nouv. Mat. Fl. Atlant. i. p. 240, and ii. p. 379) a further account of these plants is given by Pomel, and fifteen species are described, seemingly from material collected by himself, except in the case of two species which are adopted from Cosson & Durieu. It is clear from this work that Pomel possessed a considerable detailed knowledge of the group, and he has left some accurate descriptions; but unfortunately he makes no reference to the various exsiccata that had already been distributed by other botanists.

The later works of Cosson and of other writers have not maintained Pomel's separate genus *Rupicapnos* despite the distinctive features ascribed to it by its author. The demonstrated differences of the fruit and seed, however, seem of the first importance, and not only does *Rupicapnos* lack the depressed endocarp and hollowed seed of *Fumaria* but—what is not so clearly stated by Pomel—the clefts in the mesocarp which give rise to the "apical pits." On the other hand, the definition of the fruit of *Rupicapnos* as compressed, in contrast with the subglobose fruit of *Fumaria*, cannot be accepted though endorsed both by Pomel and Cosson. Except in the case of some of the annual species, the compression of the fruit in *Rupicapnos* is not appreciably greater than what usually obtains in *Fumaria*.

In addition to the fruiting differences it may be observed that the flowers of *Rupicapnos* seem to simulate those of *Sarcocapnos* rather than those of *Fumaria* in that the margins of the two outer petals, which are obsolete or nearly so in the bud stage in *Fumaria*, are considerably developed at that period and generally conceal entirely the inner petals. There appears further to be an essential difference in the structure of the upper petal, for while in *Fumaria* the margins or wings (often strongly reflexed upwards) of the apical gibbosity are truly marginal only for a short distance back from the apex of the petal, and further towards the base become extra-marginal and are prolonged in a blunt, lateral ridge, in *Rupicapnos* this prolongation is entirely wanting, the whole petal being more dorsally compressed and the margins themselves never strongly reflexed over the keel.

The presence of a gibbosity or rudimentary spur at the base of the lower petal renders this group of plants unique in the family *Fumariaceæ* in the possession of an unequally two-spurred corolla; and it is notable that the second spur is apparently never developed in the very small-flowered species and not invariably so in those in which it commonly occurs.

The consideration of these aggregate points of distinction renders it impossible to ignore the claims of *Rupicapnos* for recognition as a separate genus; and as there is a total absence of any connecting links between it and the annual species of *Fumaria*, it has been decided to follow Pomel rather

than Cosson, and to retain *Rupicapnos* as a genus. Its natural position in the family *Fumariaceæ* is between the genera *Sarcocapnos* and *Fumaria*, to both of which it approximates in certain features though possessed of other characters found in neither of them.

Classification of the Genus *Rupicapnos*.

The genus *Rupicapnos* is a small group of plants of restricted geographical range. So far as can be judged from the sparse herbarium material available for examination, including, however, the important collection in Herb. Mus. Paris, kindly lent by M. Lecomte, it embraces under four well-marked sections a number of critical forms whose limitations are not always readily defined, just as happens with the better known and more widely distributed genus *Fumaria*. Pomel, in his second account of the genus, divides his species into three subgroups, viz.: perennials with large flowers, perennials with small flowers, and small-flowered annuals. These form natural subdivisions, unconnected, so far as is known, by intermediate forms, and have been adopted accordingly. The large-flowered species, with curved, purple-tipped corollas never very broadly winged, somewhat recall *Fumaria agraria* in their floral features (Pl. **9**, figs. 4, 5). Their flowers are much more showy than in the other species of the genus, and the beauty of *F. africana* is commented on in Lamarck's original description. It is proposed to place these plants in a section *Callianthos*.

Pomel's second group, the small-flowered perennials, resembles the preceding section in habit and in fruit, albeit usually smaller in all its parts. Its flowers, however, are widely different, not only in size but in colour and form, and are quite unlike those of the *Fumariæ* (Pl. **9**, figs. 6, 7). Their colouring is uniformly whitish, with a greenish or yellowish suffusion about the apex, and the apical purple colouring of the inner petals is practically confined to their interior. The two outer petals are considerably dilated towards the apex, with spreading margins, and the inner petals are apically winged, sometimes very broadly so. These wings of the inner petals spread horizontally between the patent margins or wings of the two outer petals in such a manner as to give to the flowers a triple winged aspect, and the name *Tripteryx* therefore suggests itself for the section.

In this second section *R. sarcocapnoides*, described by Cosson, is included by Pomel, with a note that the actual plant was unknown to him. An examination of Cosson's type in Herb. Mus. Paris shows that its flowers are quite unlike those of the other members of the section, the outer petals being conspicuously dilated towards the apex and much longer than the narrowly winged, purple-tipped inner petals. The corolla indeed resembles that of a *Sarcocapnos* in miniature, as stated by Cosson, and it seems necessary to place this plant in a separate section, for which the name *Sarcocapnoides* is proposed.

Pomel's last section, comprising the annual species, is readily distinguishable by its suberect, shortly branched habit and its few-flowered racemes. Its fruits are often more compressed than those of the other sections, with a thinner and peculiarly muricate pericarp. It is proposed to name this section *Muricaria* after one of the most strongly marked species.

The first-named of these sections, *Callianthos*, readily lends itself to a subdivision into two subsections, some of the species, like *R. africana*, showing more or less narrow leaf-segments and whitish flowers, while others have distinctly broader lobes and pale purple flowers. These two subsections are termed *Africanæ* and *Pomelianæ* respectively.

It will be observed that the sequence of sections adopted in the following account of these plants places *Callianthos* last in the series. This order is followed on the assumption that in an account of the family *Fumariaceæ* the genus *Rupicapnos* follows *Sarcocapnos* and precedes *Fumaria*.

SPECIES OF *RUPICAPNOS* AND THEIR DISTRIBUTION.

In this Revision all of Pomel's fifteen species are retained (subject to two changes of name) although none of his types have been seen and synonyms are cited by him only in four cases. Herbarium material under different names, however, has been identified with six of his remaining species with some confidence, and with a strong degree of probability in the case of a seventh. The other four species have been adopted out of deference to Pomel's judgment and as the diagnoses themselves show an inherent probability of the plants being really distinct. In addition, five fresh species are described for the first time, four of these being unknown to Pomel and the fifth not distinguished by him. The total number of species of *Rupicapnos* thus becomes 20. Of these, eight belong to the large-flowered group *Callianthos*, five being *Africanæ* and three *Pomelianæ*; five are species of the section *Tripteryx*; two of *Sarcocapnoides*; and there are five known annual species or *Muricariæ*.

The geographical distribution of the genus, which as a whole is confined to North Africa from Tunis to Morocco, with one species extending to Andalusia, is of some interest. The species of the section *Callianthos* prevail towards the west and are not known in the Sahara districts. They occur on mountain rocks in many places in the Algerian province of Oran north of the plain of Schott, and extend eastward at least as far as Milianah, in the province of Algiers. In the west they have been collected at Tetuan, near Tangiers, and will presumably be found in intermediate stations in the eastern half of Morocco when that country becomes more accessible. One species reaches Europe, inhabiting the Andalusian provinces of Malaga and Cadiz.

The range of the section *Tripteryx*, which is almost exclusively Algerian, lies to the east, and is nearly contiguous with though apparently not over-

lapping that of the section *Callianthos.* Species of *Tripteryx* are found in the district of Jebel Amour, in the south-east of the province of Oran ; also near the Saharan border of the province of Algiers, as at Laghouat; and more extensively and generally in the province of Constantine, whence they extend across the Tunisian frontier in the neighbourhood of Kef.

Of the two species of the section *Sarcocapnoides,* of which little is yet known, one was collected near Batna, in the central part of the province of Constantine near the Aures Mountains, and the other at Bou-Taleb, a locality in the Algerian montane region that has not been accurately located by the writer.

Three of the annual species (*Muricariæ*) occur near Biskra, in the south of the province of Constantine, and they apparently grow there in company. Plants of this group have also been reported from Beni-Souik, near the Aures Mountains, and from Elkantara, both localities slightly to the northward. *R. muricaria* grows in the Saharan region south of the province of Algiers, as at Metlili and Ghardaia; and *R. delicatula* apparently to the west of this region, in the country south-east of the province of Oran.

Method of the Revision.

It has already been stated that the following account of the Fumitories, which includes all the known species with their well-marked varieties, and has been extended to embrace the plants referred to the separate genus *Rupicapnos*, is primarily intended for use as a supplement to the Latin edition of Olof Hammar's Monograph. A complete synonymy is therefore not printed, and it is to be understood that Hammar's synonyms are accepted unless, as happens in a few instances, they are definitely corrected. A reference is given to the original description of each species and variety, and if it exists, to an adequate Latin diagnosis. If this is not to be found, a fresh diagnosis in that language, with italicised contrasting characters after the pattern adopted in "*Fumaria* in Britain," is furnished. A number of Hammar's diagnoses, which seem satisfactory except perhaps in minor details, have been accepted, subject sometimes to some supplementary notes ; but where the Monographer's descriptions are not considered satisfactory or where the constitution of his species has been altered, fresh Latin diagnoses have been written. The descriptions of the British species and varieties dealt with in "*Fumaria* in Britain" are cited, but, as a rule, have not been repeated. References are also given to other works (often to Haussknecht's revision in 'Flora') which throw light on various species and their distribution. The known hybrid-forms are mentioned, but as these are usually barren, evanescent annuals that do not perpetuate themselves, no new names for their designation have been introduced. The terms "ex parte" and "pro parte" are applied to synonyms in the usual sense, *i. e.* when the synonym includes more than the recognized species and less than that species respectively.

Figures are cited in all cases where they are thought good enough to be helpful in identifying the plants portrayed, but it must be acknowledged that in few genera are the existing plates so generally inadequate, and the number of really good drawings of *Fumariæ* is extremely small. Some of the icones, such as Hammar's and most of those in the 'Journal of Botany,' show little more than detached flowers and fruits. The general poorness of the figures is no doubt due to the laboriously detailed work involved in depicting correctly the elaborately dissected foliage and the racemes of varying fantastic flowers of these plants.

Exsiccata are usually quoted throughout both genera except in the case of some British species where this has already been done in "*Fumaria* in Britain," and in certain British varieties of which no authentic material has yet been incorporated in any public herbaria. When the herbarium where the exsiccata has been seen is not mentioned, the plant will frequently be found either at the British Museum or at Kew. In some instances the herbarium is named owing to mixtures in sets having been noticed.

The measurements in the following descriptions are taken from dried specimens unless the contrary is stated. The length of the corolla is that of the finest flowers, and is reckoned from the apex of the upper petal to the end of its spur; the form and measurements of the fruit refer to that organ in the dry condition as seen in profile with its greatest breadth in view. In life, the flower is slightly larger than when dry, as is also the fruit, which is then likewise appreciably longer in some species owing to the presence of a distinct, fleshy neck which disappears by shrinkage as the fruit becomes dry.

The margins surrounding the green keel of the upper petal are uniformly referred to as wings in the genus *Fumaria*, and those, almost invariably smaller, similarly placed on the lower petal are simply termed margins. The wings are said to exceed the keel when they are more or less reflexed upwards and sufficiently developed to hide the keel when the flower is viewed laterally. Fruits are stated to be mucronate or mucronulate when the keel is produced at the apex into a short point bearing the deciduous style; they are described as apiculate when there is no projection of the keel and the style itself becomes detached more or less above its actual base, thus leaving a small apiculus of varying length.

It may be well to recall that although the size of the flowers is not stated in Hammar's monograph, a line depicting their actual length, and from which the size of the sepals can also be judged, is shown under each of his figures.

The sign ! implies that the plant mentioned has been seen either in life or in herbaria. Species and varieties admitted, of which no material has been seen, are marked "non vidi" (n. v.) and shown in square brackets [ ].

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FUMARIA.

Fumaria, Linn. Species Plantarum, ed. 1, 699 (1753), et Gen. Plant. ed. 5, 314 (1754), ex parte; Gaertner, De Fructibus, ii. 162 (1791), ex parte; Bernhardi in Linnæa, viii. 471 (1833); O. Hammar, Mon. Gen. Fumariarum, 2 (1857) [Nov. Act. Reg. Soc. Scient. Upsal. ser. 3, ii. fasc. post. 258 (1858)], excl. *F. corymbosa*; *Fumaria* sect. *Sphærocapnos*, DC. Syst. Nat. Veg. ii. 131 (1821); Willkomm & Lange, Fl. Hisp. iii. 878 (1880); Cosson, Comp. Fl. Atlant. ii. 83 (1883–7).

Plantæ *annuæ caulibus elongatis* ramosis diffusis vel scandentibus. Folia caulina, primordia longe petiolata, reliqua breviter petiolata vel subsessilia, *foliolis* plerisque *longe petiolatis* et segmentis secundariis vulgo petiolatis rarius decurrentibus irregulariter 2–4-pinnatisecta; petioli sæpe cirrhosi. *Inflorescentia pedicellis* etiam fructiferis omnibus *brevibus* nec elongatis *racemosa*. Bracteæ pedicellos fructiferos sæpe subæquantes nunquam multototies breviores. *Corolla unicalcarata*; petalorum exteriorum margines apicem versus in statu juvenili parum explicati vel obsoleti: *petalum superius* fere semi-cylindricum, calcaratum, superne gibbum apicem attingentem format qui *alas* basin versus *in jugum* rotundatum *laterale productas* sæpe atropurpureas habet: *petalum inferius* angustum, plus minusve canaliculatum, *haud calcaratum*, inferne gibbum apicem attingentem marginibus patentibus vel erectis circumdatum efficit; petalorum interiorum nervus medius apice modice alatus est. *Fructus* monospermus, indehiscens, nuciformis, muticus rarius mucronatus vel apiculatus, *apice* per duas rimas quæ mesocarpium perforant *bifoveolatus* est; exocarpium interdum læve vel sublæve interdum tuberculis in sicco videndis rugosum; *endocarpium sub stylo a mesocarpio disjunctum*, in hemisphæræ formâ *depressum*; *semen superne in crateris formâ excavatum*, rugâ longâ infra micropylam notatum.

Annual plants, often climbing, with long stems and cauline leaves. Inflorescence racemose with short pedicels. Lower petal never spurred. Fruit, when dry, with apical pits.

Although Hammar, in his monograph, gives a generic diagnosis of some length, a few criticisms are necessary, as well as some notes on the importance of the variations of the different organs in considering specific characters. In the first place, it is to be remembered that Fumitories, like some other weeds of cultivation, are very susceptible, especially in the

vegetative organs, to the influences of environment. This is often seen in the general habit, which, while perhaps normally markedly characteristic, is readily modified and sometimes quite obscured under abnormal conditions.

The foliage of many species shows distinct inherent differences, but throughout the genus it is exceedingly responsive to surrounding influences, always tending to become dwarfer and more compact, with narrower, thicker and more channelled segments under exposure, and larger and laxer in form, with more ample and flatter segments, in shade or in damp situations. In some species the lowest pair of leaflets is always shortly petioled, and in a few others the leaves are notable for long-mucronate or aristate segments. Both among the *Grandifloræ* and the *Parvifloræ*, however, there are several species in which the leaves are not readily distinguishable. Hammar defines the leaves as bipinnatisect in the annual species, but in most of them they are irregularly 3- or occasionally even 4-pinnatisect in normal individuals.

The relative length of the raceme and its peduncle (*i. e.* the part of the rachis below the lowest flower) is usually more or less constant in the different species, but it should be recollected that the two or three earliest racemes of a plant frequently show longer peduncles than any that follow them, and the later ones sometimes become less floriferous.

The length of the pedicels, as seen in fruit, and their direction or curvature, are generally characteristic, but in the case of species where this organ is arcuate-recurved in normal plants, it commonly becomes straight and divaricate in shade.

The form of the bracts and their length as compared with the fruiting pedicels are fairly constant and important as affording specific characters. It generally happens, however, that the two or three lowest bracts in a raceme are somewhat longer than those above them; and occasionally plants of various species will be met with in which the pedicels throughout are abnormally short and the bracts relatively more than usually long.

The sepals are valuable for diagnostic characters, for in form, size, and marginal dentation they usually show little variation in the same species, except that in shade an elongate condition sometimes obtains in which the margin may be either more or less cut than usual.

The features of the corolla are of the first importance, but they are often obscured and have proved the greatest source of confusion in the genus. This confusion is largely due to the prevalence, especially in the section *Grandiflora*, of a tendency under unfavourable environment to produce cleistogamous flowers with more or less depauperate corollas (Pl. **9**, figs. 8–10). Such flowers always tend to be pale or whitish in colour, and are sometimes reduced to less than half their normal size; their outer petals remain coherent till the corolla falls, and the margins of these petals are often quite undeveloped. Possessing no nectary, they are regularly self-fertilized, the sexual organs remaining

tightly enclosed within the connate petals. As in this rudimentary condition the characteristic features of the flower are more or less lost, it is desirable in the consideration of species to have regard to perfect flowers, with the corolla fully coloured and winged, and provided with a nectary. In these perfect flowers the lower petal is generally deflexed and free, so that the two outer petals are apically distant, in nearly every species. Hammar's definition that this is so only among the *Agrariæ*, while in the *Capreolatæ* and the *Officinales* the lower petal coheres to the others until separated at the base by the swelling fruit, cannot be accepted, for apically distant outer petals are frequently to be seen in good flowers in all three classes, as may be inferred from the observations of Jordan and other authors; and in all of them the lower petal eventually becomes detached at the base as the fruit develops. In some of the *Agrariæ*, however, the lower petal seems more caducous than in most other species.

A feature of the upper petal, not noticed by Hammar, but apparently constant throughout the genus, is that while the apical wings are formed by the margins of the petal at the very apex and for the greater part of their length, towards the base of the petal they leave the margin and are finally produced in a blunt lateral ridge. The tube of the upper petal may be regarded as laterally or dorsally compressed in proportion as this lateral ridge is distant or close to the edge of the petal.

When good flowers are present in exsiccata, a difficulty sometimes arises owing to the form of the corolla being obliterated in the process of drying, so that its dorsal or lateral compression, the shape of its spur, and the direction of the margins or wings surrounding the apical keels of the outer petals are not readily seen. In the living plant these differences are often very marked, the acute, laterally compressed corolla, with large, curved spur and narrow, strongly reflexed wings to the upper petal, seen in such a species as *F. capreolata*, being widely divergent from the obtuse, dorsally compressed corolla, with smaller, straighter spur and broad, erect-spreading wings, of *F. agraria*. In adequate exsiccata the direction of the wings and the form of the spur can usually be fairly judged after some experience, but pressed flowers are often misleading respecting the compression of the corolla-tube.

A feature of the corolla that does not appear to have been sufficiently appreciated is the constancy of its colour and of the dark marking about its apex in almost every species throughout the genus. So far as is known, there is no *Fumaria* (with the possible exception of *F. parviflora*, one variety of which (*indicoides*) seems to possess essentially pink corollas) in which the colour of fully developed flowers may be either pink or white, although pink flowers may become whitish when depauperate or shade-grown, and white ones eventually entirely suffused with pink or red after fertilization. But the essential colour, which is best seen in the later bud stage or as the flower opens, seems to be invariably constant.

The dark red or purplish markings about the apex of the corolla vary greatly in different species, being occasionally quite absent, sometimes confined to the inner petals and sometimes spreading thence, either partially or entirely, over the wings of the upper one. This marking is uniform in every species (in perfect flowers) excepting *F. Bastardii* and a few of the *Parviflorœ*. Attention is drawn to these variations under the diagnoses of the generic subsections, and they may generally be clearly seen in well dried exsiccata. A well-known peculiarity of this purplish colouring is its tendency to disperse towards the base of the corolla after fertilization and as the flower fades.

The characters of the fruit are of course among the most important, and those which are visible in the dry state are usually recognized without difficulty. A slight emendation of Hammar's diagnosis of this organ is, however, necessary, for although the apical separation of the endocarp is alluded to, no mention is made of its depression in a hemispherical form fitting the hollowed upper side of the amphitropous seed. In a few species that are widely distributed, like *F. capreolata*, *F. muralis* and *F. parviflora*, the shape of the fruit varies considerably, but otherwise there is a general uniformity in each species. The fleshy neck-like base, particularly conspicuous in the subsection *Capreolatæ*, disappears by shrinkage as the fruit dries, and the apical profile is liable to change in some species at maturity or in the dry state owing in some cases to the subsidence of a small mucronulus, or, in others, where this is larger and more beak-like, to its splitting and thus becoming retuse or emarginate. The rugosity referred to in the descriptions, and also the apical pits, are only seen when the fruit is dry, and the former is sometimes ill-marked even then in fruits that have not reached maturity. A monstrous condition of the fruit, in which it becomes swollen to more than twice its natural size, occasionally occurs. This has been noticed especially in exsiccata of *F. muralis* from Madeira and in Spanish specimens of *F. parviflora*.

From the regularity with which the more or less cleistogamous flowers in this genus develop fruit, it may be concluded that self-fertilization regularly takes place and that Fumitories are not dependent on insect visitors for their pollination. In the more northern regions of their range, such as Britain, insect visitors are apparently rare; but the flowers of *F. Bastardii* and *F. muralis* have been observed to attract the humble-bee. As might be expected under these conditions, the occurrence of hybrids is not common, and such as have been observed are almost invariably isolated individual plants that are entirely barren and evanescent.

CONSPECTUS OF SPECIES.

Section I. GRANDIFLORA.

Leaf-segments flat and relatively broad, from broadly oval to oblong or lanceolate (except in *F. Ballii*, *F. Thuretii* (partim), and *F. Reuteri*). Normal flowers large, at least 9 mm. long, exceeding those of *F. officinalis*, with the wings of the upper petal reflexed upwards and the lower petal not spathulate (subspathulate in *F. macrocarpa* and obscurely so in *F. Reuteri*).

Subsection I. AGRARIÆ.

Peduncles rarely long; pedicels usually stout. Sepals small or, more rarely, fairly large. Lower petal with spreading, more or less broad margins. Fruit usually large, coarsely rugose when dry.

Series Eu-Agrariæ.

Fruit distinctly keeled (except in *F. Ballii*), shortly beaked, mucronate or mucronulate.

* Flowers white or rosy-white.

1. *F. agraria.* Sepals small and narrow; inner petals only tipped with purple; fruit with subemarginate beak.
2. *F. atlantica.* Sepals small; inner petals only tipped with purple; wings of outer petals very broad; fruit mucronate.
3. *F. occidentalis.* Sepals fairly large; inner petals purple-tipped and wings of upper one similarly blotched; fruit with subemarginate beak; peduncles rather long.

** Flowers pink.

! Wings of upper petal not clearly purple; inner ones purple-tipped.

4. *F. rupestris.* Sepals long, lanceolate; outer petals with narrow margins; fruit shortly beaked, rather large or of moderate size.
5. *F. Ballii.* Sepals very small, oblong; outer petals with broader margins; fruit strongly mucronate, of moderate size; leaf-segments small and narrow.

!! Wings of upper petal clearly purple like the tip of the inner ones.

6. *F. major.* Sepals small; upper petal obtuse with broad wings; fruit subrotund-obovate, mucronulate.
7. *F. Gaillardotii.* Sepals larger; corolla smaller and paler, with upper petal subacute; fruit subrotund-quadrate, submucronulate.

Series Orientales.

Fruit obscurely keeled, quite obtuse.

* Fruiting pedicels arcuate-recurved.

8. *F. flabellata.* Flowers white; sepals fairly large; tip of inner petals and wings of upper one purple; fruit of moderate size; peduncles long.

** Fruiting pedicels straight.

9. *F. judaica.* Flowers white; sepals small, oblong-lanceolate; inner petals only shortly tipped with purple; fruit large.
10. *F. amarysia.* Flowers pink; sepals small, ovate-lanceolate; inner petals only obscurely tipped with purple; fruit smaller.
11. *F. macrocarpa.* Flowers pinkish, entirely without purple markings; sepals small, nearly linear; fruit very large, almost globular.

Subsection II. CAPREOLATÆ.

Peduncles long; pedicels usually stout with long bracts. Sepals large or of moderate size. Corolla generally narrow with acute upper petal (tip of inner petals and wings of upper one purple, except in *F. dubia* and *F. coccinea*), and lower petal with erect and narrow margins. Fruit small to large, usually, when fresh, with a distinct fleshy neck narrower than the dilated tip of the pedicel, and smooth to rugose when dry.

Series Eu-Capreolatæ.

Fruiting pedicels arcuate-recurved or patent. Fruit smooth or nearly so, not large.

12. *F. capreolata.* Sepals usually large; corolla narrow, white (often flushed with pink); fruit obtuse or truncate.
13. *F. dubia.* Sepals smaller; corolla narrow, pink; fruit subacute.
14. *F. purpurea.* Sepals usually large and blunt; corolla broader and more broadly winged, pink; fruit broader and truncate.

Series Macrosepalæ.

Fruiting pedicels suberect. Fruit rugose.

15. *F. macrosepala.* Sepals very large; corolla rather narrow, white, dorsally flushed with red; fruit large, mucronulate.
16. *F. berberica.* Sepals large; corolla broader and more broadly winged, white; fruit rather large, mucronulate.
17. *F. coccinea.* Sepals of moderate size; corolla very narrow, almost wingless, red; fruit rather small, obtuse or subacute.

Subsection III. MURALES.

Peduncles short or of moderate length, long only in *F. bicolor* and *F. sepium*. Pedicels usually less thickened above than in Subsections I and II (except in *F. Thuretii*). Flowers pink, except in *F. bicolor* and *F. sepium*; tip of inner petals purple. Sepals small to fairly large. Lower petal with narrow, erect or spreading margins. Fruit small or of moderate size, smooth to rugose when dry.

Series Sub-Agrariæ.

Sepals not large. Margins of lower petal spreading. Fruit rugose.

18. *F. bicolor.* Sepals oval, very small; corolla white, becoming pink; inner petals only tipped with purple; fruit small, densely rugose; racemes few-flowered on slender peduncles.
19. *F. Bastardii.* Sepals oval, less small, serrate; wings of upper petal purple or not; fruit larger, less densely rugose; racemes many-flowered on shorter peduncles.

Series Eu-Murales.

Sepals mostly of moderate size. Upper petal with purple wings, lower one with erect or more rarely spreading margins. Fruit smooth or rugulose.

* Margins of lower petal spreading; flowers large in many-flowered racemes.

20. *F. Munbyi.* Sepals ovate, dentate; fruit very small, nearly smooth.
21. *F. Martinii.* Sepals oval, subentire; fruit of moderate size, nearly smooth.

** Margins of lower petal usually erect; flowers in shorter racemes (except in *F. muralis* subsp. *neglecta*).

22. *F. sepium.* Sepals ovate or oval, subentire, fairly large; corolla rosy-white, large; fruit smooth, very obtuse.

23. *F. muralis.* Sepals ovate, dentate below (or in subsp. *neglecta* subentire); corolla of moderate size or sometimes large in subsp. *Boræi*; fruit smooth or nearly so, very obtuse or more rarely subacute.

24. *F. apiculata.* Sepals narrow, ovate-lanceolate, subentire; corolla of moderate size; fruit smooth, shortly apiculate; leaf-segments narrow and peduncles very short.

25. *F. Petteri.* Sepals sub-rhombic, rather large, toothed mostly about the middle; corolla of moderate size; fruit rugulose, subacute-elongate; racemes subsessile.

Series SUB-LATISEPALÆ.

Sepals fairly large. Wings of upper petal purple; margins of lower one very narrow, erect or more rarely spreading with obscurely dilated apex. Fruit very small, rugulose. Leaf-segments narrower than in the preceding species, and flowers smaller in subsessile racemes.

26. *F. Thuretii.* Sepals ovate, obscurely repand-dentate; fruit ovate, subacute; fruiting pedicels usually arcuate-recurved.

27. *F. Reuteri.* Sepals broader, subentire; corolla paler pink, with longer spur; fruit narrower, stipitate; fruiting pedicels patent; leaf-segments smaller.

SECTION II. PARVIFLORA.

Leaf-segments flat or channelled, relatively narrow, from oblong or lanceolate to linear or setaceous (except in *F. montana*). Peduncles usually short. Flowers not large, not exceeding 9 mm. in length, very rarely larger than those of *F. officinalis* and generally smaller, with the wings of the upper petal less reflexed upwards than in Section I and occasionally even patent; and the lower petal more or less spathulate.

Subsection IV. LATISEPALÆ.

Bracts longer than the normally stout fruiting pedicels (except in *F. rostellata*). Sepals large, at least one-third as long as the corolla and fairly broad. Fruit very small to rather large, subrotund, nearly smooth to rugose when dry.

* Flowers white, without purple tip; peduncles rather long.

28. *F. montana.* Sepals ovate-lanceolate; fruit rather large, rugose; leaf-segments broad.

** Flowers pink, with tip of inner petals and wings of upper one purple; peduncles short.

! Fruiting pedicels arcuate-recurved.

29. *F. Kralikii.* Sepals oval; fruit very small, nearly smooth; leaf-segments narrow.

!! Fruiting pedicels normally erect-spreading.

30. *F. micrantha.* Sepals nearly orbicular, more rarely ovate; fruit of moderate size, finely rugose; leaf-segments narrow.

31. *F. bracteosa.* Sepals ovate; fruit of moderate size, rugose; leaf-segments setaceous and flowers minute.

32. *F. rostellata.* Sepals broadly oval; outer petals rostellate or at least acute; fruit rather small, rugulose; leaf-segments rather narrow.

Subsection V. OFFICINALES.

Peduncles more or less short. Bracts shorter than the fruiting pedicels (except in *F. microstachys*). Flowers pink; sepals usually fairly narrow and not more than one-third as long as the corolla; tip of inner petals and wings of upper one more or less purple. Fruit of moderate size or very large, broad, truncate or retuse, rugose or rugulose when dry.

* Racemes usually long, many-flowered; pedicels not short; fruit of moderate size.

33. *F. officinalis.* Racemes 10–40 fld.; sepals ovate or ovate-lanceolate; spur of upper petal rather short; fruit at most very shortly apiculate.

34. *F. cilicica.* Racemes 30–80 fld.; sepals lanceolate; spur of upper petal longer and more curved; fruit shortly but conspicuously apiculate.

35. *F. Boissieri.* Racemes very dense, with longer peduncles; sepals lanceolate; spur as in *F. cilicica*; fruit with longer apiculus.

** Racemes short, few-flowered; pedicels short; fruit very large.

36. *F. microstachys.* Sepals ovate; flowers smaller than in preceding species; fruit without apiculus.

Subsection VI. MICROSEPALÆ.

Peduncles short or obsolescent (except in *F. australis*). Fruiting pedicels stout or slender, with variable bracts. Sepals very small or even obsolete, rarely one-fourth as long as the corolla and always narrower than its tube. Tip of inner petals purple except in some forms of *F. asepala* and *F. parviflora*. Fruit small or of moderate size, mostly subrotund, very rarely broad, rugose or rugulose when dry.

Series AMBIGUÆ.

Flowers pink, 5–7 mm. long; sepals 1·5–2 mm. long; wings of upper petal reflexed upwards, except in *F. australis*.

37. *F. abyssinica.* Bracts fully equalling the short fruiting pedicels; wings of upper petal obscurely purple; fruit subacute or obtuse, apiculate.

38. *F. australis.* Bracts broad, much exceeding the short pedicels; wings of upper petal obsolescent, deflexed; fruit subacute, apiculate; racemes dense, long-peduncled.

39. *F. Jankæ.* Bracts rather shorter than the longer pedicels; wings of upper petal purple; fruit acuminate.

Series EU-MICROSEPALÆ.

Flowers pink or white, rarely exceeding 6 mm. long; sepals minute (·5–1·5 mm. long) or absent; wings of upper petal variable.

* Flowers pink, with wings of upper petal reflexed upwards.

40. *F. Schleicheri.* Bracts less than half as long as the long, slender pedicels; flowers deep rose, with wings of upper petal purple; fruit rather small, apiculate; plant slender.

41. *F. microcarpa.* Bracts more than half as long as the short pedicels; flowers very small, lighter pink, with wings of upper petal purple; fruit very small, apiculate; plant dwarf.

42. *F. indica.* Bracts about as long as the pedicels or longer; flowers purplish pink, with wings of upper petal at most obscurely purple; fruit of moderate size, subtruncate, rarely apiculate; plant robust with very decompound foliage.

** Flowers pink, with erect-spreading or patent (rarely clearly purple) wings to the broad upper petal.

43. *F. Vaillantii.* Upper petal emarginate with ascending spur; fruit of moderate size or rather small, obtuse, rugose; plant usually rather slender with linear-oblong leaf-segments and shortly peduncled racemes.

44. *F. Schrammii.* Flowers smaller and paler, with emarginate upper petal and deflexed spur; fruit smaller, apiculate, rugulose; plant usually slender with narrower leaf-segments and mostly subsessile racemes.

*** Flowers white (sometimes flushed with pink), with erect-spreading, patent or deflexed wings to the broad upper petal.

45. *F. asepala.* Sepals usually wanting; outer petals both emarginate, with no purple marking; fruit apiculate, rugulose; plant slender, with flat, linear-oblong leaf-segments.

46. *F. parviflora.* Sepals usually present; outer petals not emarginate, the wings of the upper usually with a purple blotch; fruit often subacute, rugose; plant robust, usually with channelled, linear leaf-segments.

Sectio I. GRANDIFLORA.

Grandifloræ, Pugsley, *Fumaria* in Britain, 5 (1912). *Capreolatæ* et *Agrariæ*, Hammar, Mon. 24 & 37 (1857); *Latisectæ*, Haussknecht in Flora, lvi. (new series xxxi.), 513 (1873).

Foliorum laciniæ planæ, late ovales usque ad anguste oblongæ vel lanceolatæ (in *F. Ballii, F. Thuretii* (partim) et *F. Reuteri* angustiores), sæpius mucronatæ. Flores normales quam in *F. officinali*, L. majores, plus 9 mm. longi; petalum superius apice superne gibbum efficit, cujus margines, sicut alæ, valde sursum reflexi (raro erecto-patentes) sunt; petalum inferius apice inferne gibbum format, qui margines erectos vel patentes nunquam apice abrupte dilatatos habet. Petala interiora angusta apicem versus plus minusve sursum curvata.

Subsectio I. AGRARIÆ.

Agrariæ, Haussk. in Flora, lvi. 550 (1873); Pugsley, Fum. in Brit. 42 (1912); Hamm. Mon. 37 (1857), ut sectio.

Pedunculi breves aut longi pedicellis plerumque apice multo incrassatis præditi. Bracteæ longitudinis variabilis, sæpe tenuiter acuminatæ. Sepala plus minusve dentata, raro corollæ tertiâ parte longiora vel ejus tubo latiora. Petala exteriora obtusa vel subacuta; inferius marginibus patentibus latiusculis qui superne nonnunquam paulum dilatati apicem attingunt. Fructûs sæpissime quam in aliis subsectionibus majores, nonnunquam maximi, semper siccitate plane tuberculato-rugosi.

In this subsection the varied development of the purple colouring about the apex of the corolla is characteristic of the different species. *F. major*, *F. Gaillardotii*, and *F. flabellata* have the tips of the inner petals and the wings of the upper one entirely purple. *F. occidentalis* is similarly marked, except that the purple wings show clear, white margins; in *F. rupestris* the colouring of these wings is obscure and inconstant. In *F. agraria*, *F. atlantica*, *F. Ballii*, *F. judaica*, and *F. amarysia* the inner petals only are purple-tipped, although in the first-named species the wings of the upper petal often become suffused with a dull rose-colour. In *F. judaica* this dark tip is distinctly contracted towards the apex, and in *F. amarysia* it becomes both short and obscure. Finally, the purple colour is entirely absent in *F. macrocarpa*.

With the exception of *F. flabellata*, the plants of this subsection generally show somewhat narrower leaf-segments than the *Capreolatæ* and the series *Eu-Murales* of the *Murales*.

* Series **Eu-Agrariæ**.

Fructûs plane carinati (*F. Ballii* exceptâ), breviter rostrati, mucronati vel mucronulati.

1. FUMARIA AGRARIA, Lagasca, Elenchus Pl. Hort. Matrit. et Gen. Spec. Pl. Nov. 21 (1816); Hamm. Mon. 38, excl. var. *major* (1857); Haussk. in Flora, lvi. 555 (1873); Willkomm & Lange, Fl. Hisp. iii. 881 (1880). (Pl. **9**, fig. 1.)

Icon. Hamm. *l.c.* tab. iv.

Exsicc. Porta & Rigo, Iter II Hispanicum, 1890, No. 228, Cartagena! Bourgeau, Pl. d'Espagne, 1849, No. 21, Seville! Bourgeau, Pl. d'Esp. et de Portugal, 1853, No. 1756, Algarve! Balansa, Pl. d'Algérie, 1852, No. 628, Mostaganem!

β. mauritanica, Haussk. *l.c.* 555.

Exsicc. Bourgeau, Pl. d'Algérie, 1856, Tlemcen, in Hb. Boissier, ut *F. agraria*!

Bracteis pedicellos breves (circa 3 mm. longos) subæquantibus, sepalis angustis (5 mm. longis, 1 mm. latis), lanceolatis, integriusculis, longe acuminatis a typo differt.

Wolley-Dod, Fl. Calpensis, No. 240, from Algeciras, seems to approach this variety.

γ. chilensis, Parlatore, Mon. Fum. 73 (1844); Haussk. *l.c.* 556.

This variety, which seems scarcely separable from the specific type except for its smaller and more markedly beaked fruits, occurs occasionally in Spain, as may be expected, as well as in Chili and Peru. Judging from herbarium material, it is by no means the prevalent form of the species in South America.

There is a Portuguese example of *F. agraria* in the Sloane Collection in Herb. Mus. Brit. (H.S. 326/1549) labelled "*F. latiore folio spica laxiore e Lisbon*."

Lagasca's diagnosis of this species is meagre and unsatisfactory, but Jordan, in dealing with *F. major*, Bad. (Pugillus, p. 6), describes an authentic specimen in De Candolle's Herbarium which leaves no doubt respecting its identity. It is to be regretted that this fine fumitory has apparently never been adequately figured.

F. agraria is almost unique among the *Grandifloræ* in the form of its upper petal which, while much dorsally compressed and very broad about the apex with erect spreading wings, is remarkably narrowed towards the base and terminates in a relatively small and laterally compressed spur. Another notable feature, only seen in the fresh state, is the yellow colour which pervades the base of the corolla almost till maturity. This peculiarity is

correctly noted in Hammar's diagnosis as "lutescentia," and the relatively dull tints characterizing the flowers of this species are probably due to this yellow suffusion of the rosy-white corolla.

A further distinctive feature of *F. agraria* is the polished surface of the dried fruits and their extremely shallow apical pits.

Of other described forms of this plant Haussknecht's var. *algerica*, as represented in Herb. Kew, belongs to *F. major*, Bad., as might be expected from the remarks respecting the sepals.

An authentic specimen, also at Kew, of var. *elata*, Ball in Journ. Linn. Soc. xvi. 315 (1878), which the author suggests may be identical with *F. rupestris* var. *laxa*, Boiss., has the aspect of a distinct, small-flowered variety of *F. agraria*, but as its fruit is now missing, further confirmation is desirable before this can be established.

F. agraria subsp. *Merinoi*, Pau ap. Merino, Fl. Galicia, Suppl. iii. 508 (1909), seems from its description to differ essentially from the type only by its linear-lanceolate sepals; and hence it is perhaps a form of Haussknecht's variety *mauritanica*.

Material of *F. agraria* has been observed from Spain, Portugal, Morocco, Algeria, Tunis, and Sicily, as well as from South America, where it seems to be extensively naturalized.

2. FUMARIA ATLANTICA, Cosson & Durieu ap. Haussk. in Flora, lvi. 558 (1873).
F. agraria γ. *atlantica*, Cosson, Comp. Fl. Atlant. ii. 90 (1883–1887), non Ball.

Exsicc. Bourgeau, Tizi Tsennent, Alger, 1856, et cult., in Hb. Boissier! E. G. Paris, Iter Boreali-Africanum, 1869, No. 205, Sidi Mecid, in cultis, Constantina, ut *F. agraria*! Cosson, Djebel Zaghouan, Tunis, 1883, in Hb. Kew!

Fumaria annua, *robusta*, foliis irregulariter 2–3-pinnatisectis, foliolis in lobos oblongos acutos vel mucronatos fissis. *Racemi laxiusculi*, sub-20-flori, *pedunculos* mediocres *vix superantes*. *Bracteæ* lineari-oblongæ, cuspidatæ, *pedicellos* 5–6 mm. longos *erecto-patentes* paululum incrassatos *subæquantes*. *Sepala*, 3–4 *mm. longa*, 1·5–2 *mm. lata*, *ovato-lanceolata*, acuminata, parce irregulariter *serrato-dentata*, albida, nervo dorsali angusto rubicundo, corollæ tubo angustiora. *Corolla maxima*, 14–16 *mm. longa*, *roseo-albida*; *petalo superiore obtuso, lato, alis albidis latissimis* brevibus patenti-reflexis apicem attingentibus et calcare breviusculo prædito; *petalo inferiore* obtuso *marginibus latissimis* (4–4·5 *mm. lato*) *patulis* albidis apicem attingentibus subspathulato; petalis interioribus sursum curvatis apice atropurpureis. *Fructûs maximi*, 3·5 mm. longi, 3 mm. lati, *subrotundo-obovati*, carinati, *cum mucrone* distincto persistente *obtusiusculi* et inferne angustati, in sicco apicis foveolis latis obscuris *dense tuberculato-rugosi*.

β. *platyptera*, var. nov.

Exsicc. Reverchon, Plantes d'Algérie, 1898 (Kabylie), No. 3, ut *F. vagans*, Jord.!

A typo differt bracteis brevioribus pedicellos dimidios vix superantibus, floribus paulo minoribus, et præsertim *fructibus multo minoribus* circa 2·75 mm. longis ac latis cum mucrone brevissimo *obtusissimis*.

Hæc species, quæ Algeriam et Tunisiam habitat, per flores pallidos maximos et petalorum exteriorum (præsertim inferioris) alas latissimas notabilis est. A *F. agrariâ* sepalis tenuibus anguste carinatis, corollis latioribus, fructuque plus minusve mucronato densius rugoso differt. *F. major*, Bad. corollâ angustiore alis atropurpureis reflexis roseâ et fructibus minoribus obtusioribus præcipue distinguitur, sed quod ad fructum pertinet, varietati *platypteræ* simillima est.

The diagnosis of this fumitory, the finest-flowered of all the genus, is based on Boissier's specimens, together with Cosson's plant at Kew, the E. G. Paris example in Herb. Mus. Brit., which shows extremely fine flowers but unfortunately no fruit, and Reverchon's plant in Mr. C. Bailey's collection. The last-named bears fruit more like that of *F. major* than of Boissier's type, but the remarkably broad wings and the colouring of its corolla render it impossible to mistake its closest affinity, and it is therefore placed as a variety under *F. atlantica*.

3. Fumaria occidentalis, Pugsley in Journ. Bot. xlii. 217 (1904); Fum. in Brit. 43 (1912).

Icon. Journ. Bot. *l.c.* tab. 462.

Exsicc. Dörfler, Herb. Norm. No. 4814!

This species is perhaps the *F. vulgaris corubensis alba* (sic) of Parkinson (Theat. Bot. 287 (1640)), noted as growing in cornfields in Cornwall.

In addition to the characters already given whereby this plant may be distinguished from *F. agraria*, Lag., it may be remarked that the colour of its corolla is a clear rosy-white, quite without the yellow and greyish tints which mar the brightness of the flowers of Lagasca's plant, and its upper petal is less obtuse with the wings distinctly reflexed upwards as in *F. major*, Bad.

4. Fumaria rupestris, Boissier & Reuter, Pugillus, 4 (1852); Hamm. Mon. 40 (1857); Haussk. in Flora, lvi. 556 (1873).

Icon. Hamm. *l.c.* tab. 6 (mala).

Exsicc. Boissier & Reuter, Iter Algeriensi-hispanicum, 1849, Tlemcen, in Hb. Kew! Warion, Pl. Atlant. Sel., 1878, No. 112, Tlemcen! Reverchon, Pl. de l'Andalousie, 1890, No. 569, Ronda, ut *F. agraria*!

Boissier's var. *laxa* (*F. arundana*, Boiss. ap. Willkomm & Lange, Fl. Hisp. iii. 880 (1880)) appears to have been described from a shade-form,

Specimens collected at Ronda by Mr. C. Bucknall in 1907 do not accord with Boissier's diagnosis and seem indistinguishable from well-grown African examples.

Hausskneclit's forms *diffusa* and *umbrosa* (Flora, *l. c.*) also appear to be shade-forms, and it may indeed be doubted whether Boissier's original account of the species was taken from a normal plant.

In well-grown individuals, the corolla of *F. rupestris* is pale pink, with an occasional suffusion of purple in the wings of the upper petal. When shade-grown, it becomes whitish, with the purple colour confined to the tips of the inner petals as in *F. agraria*.

F. rupestris is remarkable among the *Agrariæ* for the narrowness of its corolla and the wings of the outer petals, and on this ground alone might be placed with almost equal propriety with the *Murales* near *F. Bastardii*. Its fruit, however, although not very large, is of markedly Agrarian form.

F. rupestris var. *maritima*, Battandier in Bull. Soc. Bot. Fr. xxxii. 336 (1885), is apparently referable to *F. bicolor*, Sommier.

5. FUMARIA BALLII, sp. nov. (Pl. **10**.)

F. agraria subsp. *tenuisecta*, Ball in Journ. Bot. xi. 297 (1873); Spic. Fl. Marocc. in Journ. Linn. Soc. xvi. 316 (1878).

Exsicc. J. Ball, Iter Maroccanum, Aït Mesan, 1871, in Hb. Kew!

Fumaria annua, ut videtur, *habitu* laxiusculo et *satis robusto*. *Folia* pallide virentia, irregulariter 3–4-*pinnatisecta*, foliolis in *lacinias* parvas planas *angustas lineari-oblongas* acutas vel mucronatas fissis prædita. *Racemi laxiusculi multiflori* (15–25-flori), *pedunculos* breves *multo superantes*. *Bracteæ* lineari-lanceolatæ, obscure serratæ, tenuiter acuminatæ, *pedicellis* fructiferis *erecto-patentibus* longiusculis apicem versus modice incrassatis *dimidio breviores*, sed infimæ interdum paulo longiores. *Sepala minima, circa 2 mm. longa*, 1 *mm. lata*, *oblonga*, acuminata, *obscure dentata*, præter nervum angustum viridiusculum rosea, in fructu juniore persistentia. *Corolla* 12–14 *mm. longa*, *rosea*, ut in *F. rupestri* angusta; *petalo superiore alis roseis* reflexis carinam vix superantibus sed apicem attingentibus et calcar tenue versus longe productis *obtuso*; *petalo inferiore* obtusiusculo *marginibus latiusculis patulis* apicem attingentibus; petalis interioribus sursum curvatis apice purpureis. *Fructûs modici*, sine mucrone 2·5 mm. longi, 2 mm. lati, *subrotundi*, obsolete carinati, *obtusiusculi* et persistenter *grosse mucronati*, inferne multo angustati, siccitate apicis foveolis obscuris sed latiusculis dense sed tenuiter *tuberculato-rugosi*.

Hæc Fumaria distinctissima quæ subsectionis *Agrariarum* flores fructûsque habet, per folia decomposita eis *F. Kralikii* et *F. micranthæ* similia mirabilis est. Inter affines *F. rupestri* proxima est, sed præter foliorum differentiam bracteis brevioribus, sepalis minimis et fructibus minus rugosis, grosse mucronatis potius quam rostratis, facile distinguitur.

F. Ballii in Mauritaniâ habitat, ubi cl. J. Ball in regione inferiore Atlantis Majoris in convalle Aït Mesan ad 1400 m. specimen unicum legit.

This remarkable and very rare Fumitory has been named after its discoverer to avoid confusion with *F. tenuisecta* Syme, Eng. Bot. ed. 3, i. 113 (1863).

The accompanying plate has been drawn from the single known specimen in Herb. Kew.

6. Fumaria major, Badarro in Moretti, Bot. Ital. i. 10 (1826); Jordan, Pugillus, 6 (1852); Haussk. in Flora, lvi. 552 (1873), ex parte; Rouy & Foucaud, Fl. France, i. 176, ut forma *F. agrariæ* (1893). *F. agraria β. major*, Hamm. Mon. 38 (1857).

F. major floribus dilute purpureis, Magnol. Hort. Monspel. 82 (1697). The Sloane Herbarium contains, under Magnol's name, two specimens of this species, H.S. 58/146 & H.S. 166/322, the former from Montpellier.

Icon. Reichb. Plantæ Criticæ, i. 1–113, No. 1222.

Exsicc. Billot, Fl. G. & G. No. 3308! Société Dauphinoise, 1880, Nos. 2354! et bis!

Fumaria annua, *robusta*, basi ramosa, internodis longis laxa et diffusa, raro petiolis cirrhosis scandens. Folia irregulariter 2–3-pinnatisecta, foliolis in lobos oblongos acutos vel mucronatos fissis prædita. *Racemi* plus minusve *laxi*, 10–20- (raro plus 15-) flori, *pedunculos* sæpissime breviusculos *superantes*. *Bracteæ* lineari-oblongæ, apice interdum serrulatæ, cuspidatæ vel acuminatæ, *pedicellos* fructiferos apice incrassatos *suberectos* vel patenti-erectos *subæquantes*. *Sepala* eis *F. officinalis* similia, 3–3·5 *mm. longa*, 1·5–2 *mm. lata*, *ovato-lanceolata* vel ovata, vix peltata, acuminata, irregulariter *inciso-dentata*, præter nervum dorsalem rubicundum rosea, corollæ tubo angustiora. *Corolla magna*, 12–14 *mm. longa*, *rosea*; *petalo superiore obtuso, lato,* dorsum compresso, calcar deflexum versus sulcato, *alis* intense *atropurpureis* reflexis brevibus apicem attingentibus et carinam multo excedentibus prædito; *petalo inferiore marginibus latis patulis* roseis apicem attingentibus obtuso et sæpe sub-spathulato; petalis interioribus sursum curvatis apice atropurpureis. *Fructûs magni*, 2·5–3 mm. longi ac lati, *subrotundo-oborati*, *obtusissimi* vel subtruncati, *cum mucronulo* interdum obsoleto carinati et paululum compressi, in vivo inferne in stipitem obsoletum pedicelli apicem subæquantem angustati, siccitate apicis foveolis latis obscuris *dense tuberculato-rugosi*.

β. spectabilis, Rouy, Suites à la Fl. de France, i. 31 (1887). *F. spectabilis*, Debeaux, Recherches Fl. Pyr.-Orient. i. 20 (1878); Rouy & Foucaud, Fl. Fr. i. 176, ut forma *F. agrariæ* (1893).

Exsicc. Magnier, Fl. Selecta No. 2387!

A typo differt *foliorum segmentis angustioribus* lanceolatis vel lineari-oblongis; racemis densioribus; *corollis* pallidioribus *minoribus* (circa 12 mm.

longis) petalo superiore angustius alato apiculato; fructibus obsolete mucronulatis.

Of *F. spectabilis*, Bischoff, Del. Sem. Hort. Bot. Heidelberg, p. 4 (1849), no authentic specimen has been seen, but plants raised from seed received from Jordan under this name seem identical with the narrow-leaved Pyrenean form described by Debeaux and other French authors.

Although Bischoff says of his *F. spectabilis* "patria ignota," Jordan (Pugillus, p. 6) states that it is indigenous in Istria and South Italy—an assertion copied by later writers. The examples seen from these countries, however, appear distinct from the French *F. spectabilis* and identical with the allied forms inhabiting Greece and Syria. These are separated as a species under the name of *F. Gaillardotii*, Boissier.

γ. *algerica*, var. nov.

F. agraria var. *algerica*, Haussk. *l. c.* 555 (1873).

Exsicc. Bourgeau, Pl. d'Algérie, 1856, Maison Carrée, Alger, Cosson, 1854, ut *F. agraria*! Reverchon, Pl. d'Algérie, Kabylie, 1896, No. 3, ut *F. muralis*! [The sheet of this in Herb. Zurich is a mixture of the true plant with *F. flabellata*, Gasp.] Société Dauphinoise, 1879, No. 286 bis, ut *F. agraria*!

Foliorum segmenta quam typi paulo angustiora. *Racemi* primo densi tandem elongati, *multiflori* (sæpius plus 20-, nonnunquam 40-flori). Bracteæ pedicellis longiusculis (5–6 mm. longis) breviores. Sepala 3–4 mm. longa. *Corolla speciosa*, 13–15 mm. longa, *petalo inferiore marginibus* quam in typo *latioribus* usque ad 3 mm. lato. *Fructûs obtusiusculi* potius quam obtusissimi mucronulati.

It is not easy to understand why Haussknecht placed this showy African plant under *F. agraria*. Not only by its pink, dark-tipped flowers, but through its toothed sepals and its densely tubercular-rugose fruits it is closely related to the plant of Badarro.

Of the specific type two forms, perhaps varietally distinct, seem to be widely distributed in the Riviera: one a dwarf, compact plant, with relatively small flowers and fruits, the former very deeply coloured; the other a stronger, laxer form, with larger but lighter-coloured flowers in laxer racemes, and larger fruits.

When growing, the rich pink, almost black-tipped flowers of *F. major* are very handsome.

Hybrid individuals between this species and *F. capreolata*, apparently quite barren, have been collected and distributed from the South of France under the name of *F. Burnati*, Verguin in Rouy, Rev. Bot. Syst. ii. 122 (1904).

The range of *F. major* extends from Western Liguria across the South of France into Catalonia; the var. *spectabilis* grows in Narbonne and the Eastern Pyrenees, also in South Russia (Astrakan, Becker, 1876!); the var. *algerica* in Algeria.

7. Fumaria Gaillardotii, Boissier, Fl. Orient. i. 139 (1867). *F. major*, auct., ex parte, non Badarro ; *F. spectabilis*, auct., ex parte, non Bischoff? *F. drepanensis*, Lojacono Pojero in Malpighia, fasc. ii.–iii. 110 (1906).

Exsicc. Neugebauer, Fl. Exsicc. Austro-Hungarica No. 2898, ut *F. major*! Heldreich, Herb. Fl. Hellenicæ No. 68, ut *F. major*! Todaro, Fl. Sicula Exsicc. No. 222, ut *F. major*!

Fumaria annua, *robustissima*, internodis longis parce ramosa, diffusa vel petiolis cirrhosis scandens. Folia irregulariter 2–3-pinnatisecta, foliolis in lobos cuneiformes mucronatos, oblongos obtusos vel rarius lanceolatos acutos fissis. *Racemi laxiusculi*, 10–16- (sæpius 10–12-) flori, *pedunculos* crassos *superantes*. *Bracteæ oblongæ*, cuspidatæ, præter nervum viridiusculum albidæ, *pedicellos* fructiferos *suberectos* apice valde *incrassatos subæquantes*. *Sepala* 3–4 *mm. longa, circa 2 mm. lata, ovata*, peltata, acuta, plus minusve *inciso-dentata*, præter nervum dorsalem obscurum albida, corollæ tubo æquilata. *Corolla* 10–12 (rarius 13) *mm. longa, pallide rosea*; *petalo superiore obtusiusculo*, calcare adscendente et *alis atropurpureis* reflexis apicem attingentibus carinamque paulo excedentibus prædito ; *petalo inferiore marginibus latiusculis patulis* roseis apicem vix attingentibus subacuto ; petalis interioribus sursum curvatis apice atropurpureis. *Fructûs magni*, 2·5 mm. longi et paululum latiores, *subrotundo-quadrati* vel subrotundi, *obtusissimi* truncati vel raro subemarginati, *obsolete mucronulati* et carinato-compressi, in vivo, ut videtur, in stipitem quam pedicelli apex multo angustiorem abrupte angustati, siccitate apicis foveolis mediocribus obscuris *dense tuberculato-rugosi*.

Hæc species *F. majori*, Bad. valde affinis est, sed differt habitu etiam robustiore, pedunculis pedicellisque crassioribus, bracteis sepalisque latioribus, corollis pallidioribus minoribus petalo superiore angustius alato calcareque majore præditis, et fructibus subrotundis potius quam obovatis magis carinato-compressis foveolisque minoribus notatis.

F. agraria, Lag. præter floris majoris colorem formamque sepalis plus minusve lanceolatis apice subintegris diu persistentibus et fructûs valde compressi carinâ in rostrum emarginatum productâ facile dignoscitur.

Floris colore et magnitudine, sepalis majoribus, fructibus retuse rostratis *F. occidentalis*, Pugsley, etiam diversa est.

F. rupestris, Boiss. floribus angustis, sepalis longissimis et fructibus acutiusculis minoribus cum *F. Gaillardotii* confundi non potest.

F. Gaillardotii in Syriâ, in Egypto, in Cretâ (Heldreich, Heracleum, 1846, ut *F. flabellata*!), in Græciâ, in Dalmatiâ, in Istriâ, in Siciliâ et forsan in Italiâ australi invenitur.

F. Gaillardotii, although obviously near *F. major* and generally united with it by recent authors, seems to be a more Eastern plant which is specifically distinct owing to several minor but constant points of divergence, and especially by its different sepals and corolla. In spite of its wide distribution it appears to show little variation, except in the breadth of the leaf-segments,

and its general aspect is that of a coarse and rampant *F. major* with remarkably poor flowers. It is notable that neither Boissier nor Halácsy recognizes the identity of the Greek with the Syrian form.

There is a specimen of this plant in Herb. Mus. Brit. "*F. agraria*, Lag.—In arvis prope Nebi-Seidone, circa Sidonem Syriæ, d. 13 Martii, 1860, coll. Gaillardot."

** Series **Orientales**.

Fructûs obscure carinati, omnino obtusi.

8. Fumaria flabellata, Gasparrini in Rendic. Accad. Scien. Napoli, i. 51 (1842); Hamm. Mon. 41 (1857); Haussk. in Flora, lvi. 542 (1873). *F. alexandrina*, Gasp. in Rendic. Accad. Scien. Napoli, i. 50 (1842), non Ehrbg. ex Hammar, pro parte; *F. capreolata* var. *β*, Parlatore, Mon. Fum. 77 (1844); *F. Gasparrinii*, Bubani, Fl. Pyr. iii. 276 (1901)?

Icon. Hamm. *l. c.* tab. 5.

Exsicc. Todaro, Fl. Sicula Exsicc. No. 221, Palermo! Reverchon, Pl. d'Algérie, 1896 (Kabylie), No. 103, ut *F. capreolata*!

This beautiful fumitory, which bears a resemblance to *F. capreolata* owing to its long-peduncled racemes of white, dark-tipped flowers borne on recurved pedicels, is included by Haussknecht with his *Capreolatæ*. Since the corolla, however, is distinctly Agrarian in form, it seems preferable to follow Hammar in placing it here. As in *F. capreolata*, the pedicels are frequently straight in shade-grown plants.

F. flabellata is very finely represented in the exsiccata "Reverchon, Pl. d'Algérie, 1896 (Kabylie), No. 103," as *F. capreolata*.

F. alexandrina, described by Gasparrini, seems to be a rampant form of this species, as identified by Parlatore. Gasparrini, whose type of *F. flabellata* appears to be a dwarf form from a native habitat, did not recognize that the two plants were conspecific.

F. ambigua, Lojacono Pojero, Fl. Sicula, 62 (1888), is reduced by Nicotra in Le Fum. Ital. p. 60, to a variety *β. ambigua* of this species, differing from the type by its rosy flowers and larger fruits. Authentic material of this plant has not been examined.

Examples of *F. flabellata* have been noted from South Italy, Sicily, and Algeria, but none from Spain. The specimens met with under this name from Istria and Dalmatia have proved referable to *F. capreolata*, *F. Gaillardotii* or *F. judaica*, but a Dalmatian example (Botteri, Cazziol!) exists in Herb. Mus. Brit. under the name of *F. speciosa*.

An unnamed, fragmentary plant in Herb. Kew, collected by Miss R. A. Bainbridge in South Morocco in 1907, resembles *F. flabellata* in its large, white, dark-tipped flowers, but its pedicels are straight and such fruits as it shows nearly smooth. This may prove to be an undescribed species.

9. Fumaria judaica, Boissier, Diag. Pl. Or. ii. No. 8, p. 15 (1849); Haussk. in Flora, lvi. 551 (1873). *F. alexandrina*, Ehrbg. ex Hamm. Mon. 43 (1857).

Icon. Hamm. *l. c.* tab. 5, ut *F. alexandrina.*

Exsicc. Bornmüller, Iter Syriacum, 1897, No. 46, Jaffa! Letourneux, Pl. Ægyptiacæ, No. 231, Mariout!

β. *insignis*, var. nov.

Exsicc. K. Untchj, Kaiserwald, Pola, 1904, ut *F. flabellata*! Pichler, Dalmatia, in agris circa Spalato, 1870, ut *F. agraria* (partim)!

Racemis paucifloris pedunculos subæquantibus, *floribus multo majoribus* (12–13 mm. longis) petalo superiore latius alato subacuto et breviter rostellato, fructibus subrotundis apice abrupte truncatis obsolete foveolatis sine maculis nigris a typo differt.

Hæc pulchra varietas habitat in Istriâ, prope Polam, et in Dalmatiâ, circa Spalato, ubi ex Egypto aut Palestinâ forsan introducta est.

F. flabellata longe distat pedunculis longioribus, pedicellis fructiferis arcuatis recurvis nec erecto-patentibus, sepalis magnis ovatis, et petali superioris alis atropurpureis nec albidis.

In the case of *F. judaica*, Hammar's description, though taken from the living plant, seems unsatisfactory respecting the calyx and the fruit. All the specimens examined show very small, oblong-lanceolate sepals, as described by Boissier and Haussknecht, and while the fruit varies in the development of its keel, no mucronulus has been observed in any dried example that has reached maturity. A feature of the fruit hitherto unnoticed is the conspicuous tubercle at the base of the inner apical pit. Good flowers are very frequently lacking in herbarium material of this species (especially of the Egyptian plant), and it is probable that the Syrian and Egyptian forms are not exactly identical, the fruiting pedicels in the latter (the form described by Hammar) being distinctly shorter. It may also prove that *F. judaica* occurs in Greece and has been confounded with the following species.

An example in Herb. Mus. Brit. from Central Africa (Oudney, Denham & Clapperton, 1822–4, as *F. officinalis*!) is seemingly referable to *F. judaica*.

10. Fumaria amarysia, Boiss. & Heldr. in Fl. Orient. i. 138 (1867); Haussk. in Flora, lvi. 550 (1873).

Exsicc. Heldreich, Herb. Græc. Norm. No. 817!

Fumaria annua, parce ramosa, *laxa*, diffusa vel petiolis cirrhosis scandens. Folia irregulariter 2–3-pinnatisecta, foliolis in lobos oblongos mucronatos vel lanceolatos acutos fissis, infimis breviter petiolatis. *Racemi laxiusculi*, sæpius 10–15-flori, *pedunculos subæquantes.* *Bracteæ* lineari-lanceolatæ, acuminatæ, *pedicellis* mediocribus apice aliquanto incrassatis fructiferis *suberectis paulo breviores. Sepala* 1·5–2 *mm. longa*, 1 *mm. lata, ovato-lanceolata*, acuta, vix peltata, *plus minusve dentata,* præter nervum dorsalem rubicundum rosea,

corollæ tubo multo angustiora. *Corolla* 9–10 *mm. longa, pallide rosea*; *petalo superiore alis roseis* reflexis carinam superantibus apicem attingentibus et calcar versus longe productis *obtuso*; *petalo inferiore marginibus latis patulis* roseis apicem vix attingentibus subacuto, sæpe libero deflexo; *petalis interioribus* sursum curvatis, breviter et *obscure apice atropurpureis*. *Fructûs majusculi*, 2·5 mm. longi et paululum angustiores, breviter *subrotundo-obovati*, superne *subtruncati* et inferne angustati, carinâ obscurâ paululum compressi, in sicco apicis foveolis obscuris *tuberculato-rugosi*.

Hæc species proxima est *F. judaicæ*, cujus forsitan mera varietas sit, sed *F. judaica* differt habitu robustiore, pedicellis vulgo longioribus apice magis incrassatis, sepalis oblongo-lanceolatis acuminatis basi solum dentatis, corollâ majore albidâ nec roseâ, fructibus majoribus nitidis evidentius tuberculato-rugosis.

F. macrocarpa, Parl. cujus corolla ei *F. amarysiæ* subsimilis est fructibus maximis globosis longe recedit.

F. Bastardii, Bor. subsectionis *Muralium*, pro quâ cl. Boissier primo *F. amarysiam* habuit, petali inferioris marginibus angustis præsertim sed etiam bracteis brevioribus, sepalis majoribus serratis, fructibus subacutis vel obtusis nec vero subtruncatis plane differt.

Hæctenus *F. amarysia* in Græciâ solâ inventa est.

11. Fumaria macrocarpa, Parlatore, Pl. Novæ, 5 (1842), et Mon. Fum. 143 (1844); Hamm. Mon. 45 (1857); Haussk. in Flora, lvi. 559 (1873).
F. megalocarpa, Boiss. & Sprunn, Diag. Pl. Or. i. No. 1, p. 68 (1843).

Icon. Hamm. *l. c.* tab. 6.

Exsicc. Orphanides, Fl. Græca Exsicc. No. 20, Athens, ut *F. megalocarpa*! Heldreich, Herb. Græc. Norm. No. 1002, ut *F. megalocarpa*! Balansa, Pl. d'Orient, 1854, No. 128, Smyrna!

This species, recognizable at a glance by its very large, globular fruits, is remarkable also for its extremely narrow sepals and the complete absence of purple colouring from its corolla. In well-grown examples the pale, rosy flowers attain a length of 11 mm., with the linear-lanceolate sepals nearly 3 mm. long. The distant and curiously recurved lower petal depicted in Hammar's figure was noticed by Boissier as characteristic of this species, and its spreading margins are more spathulate in outline than in any other member of the *Grandifloræ*.

F. oxyloba, Boiss. Diag. Pl. Or. ii. No. 8, p. 14 (1849), appears to be a shade-form rather than a true variety of *F. macrocarpa*.

Subsectio II. **CAPREOLATÆ.**

Capreolatæ, Haussk. in Flora, lvi. 539 (1873); Pugsley, Fum. in Brit. 5 (1912); Hamm. Mon. 24 (1857), ut sectio, ex parte.

Pedunculi longi pedicellis sæpissime apice multo incrassatis præditi. Bracteæ raro quam pedicelli fructiferi multo breviores. Sepala plerumque magna, apicem versus integriuscula, raro quam corollæ tertia pars breviora

ejusque tubum latitudine sæpissime superantia. Corolla sæpius angusta; petalo superiore alis apicem haud attingentibus acuto; petalo inferiore acuto marginibus erectis angustis apicem haud attingentibus. Fructûs parvi, mediocres vel magni, in vivo plerumque stipite carnoso distincto quam pedicelli apex incrassatus angustiore præditi, siccitate læves usque ad rugosi.

The wings of the upper petal, as well as the tips of the inner ones, are dark purple in *F. capreolata*, *F. purpurea*, *F. macrosepala*, and *F. berberica*. In *F. dubia* and *F. coccinea* this dark colour is obscure or wanting, and in the last-named the wings themselves are obsolescent.

* Series **Eu-Capreolatæ.**

Pedicelli fructiferi arcuato-recurvi aut saltem patentes; fructûs læves vel rugulosi.

12. Fumaria capreolata, Linn. Spec. Plant. 701 (1753); Hamm. Mon. 24 (1857); Pugsley, Fum. in Brit. 6 (1912). *F. pallidiflora*, Jordan in Schultz Archives, 305 (1854). (Pl. **9**, fig. 2.)

In Hammar's Monograph Ray's *F. major scandens flore pallidiore* (Hist. i. 405 (1686)), cited by Linnæus, is omitted from the synonymy of this species. The omission is not without justification, for Ray's remarks betray no acquaintance with *F. capreolata*, and none of the exsiccata in the Sloane Herbarium under his name belongs to this species, being all, except one doubtful fragment (probably *F. muralis* subsp. *Boræi*), rampant forms of *F. officinalis*, as is also a specimen similarly named in the contemporary Herb. Dubois at Oxford. It may thus be reasonably concluded that rampant forms of *F. officinalis* were the recognized *F. major scandens flore pallidiore* of the British botanists of that period. The Sloane Herbarium contains a good example of *F. capreolata* (H.S. 58/146) under Bauhin's name (Pinax, 143), and there is a British specimen of var. *Babingtonii* in Herb. Dubois, labelled "*F. scandens altera* Cæsalp."

Icones. Savi, Mat. Med. tab. i, ic. 1; Sturm, Deutschlands Flora, i. 62. 13; Flora Danica, tab. 2359 (forma umbrosa); Hamm. *l. c.* tab. iii. (forma sepalis insolite dentatis); Journ. Bot. xl. tab. 436, fig. 2, ut *F. speciosa*.

Exsicc. Bourgeau, Fl. Pyr.-Espag. No. 391! Neugebauer, Fl. Exsicc. Austro-Hungarica, No. 2899!

! Sepala typi vel paulo breviora, subintegra; corolla rubescens.

β. *speciosa,* Hamm. Mon. Slägt. Fum. 25 (1854), et Mon. 25 (1857). *F. speciosa*, Jord. in Cat. Grenoble, 15 (1849), et Linnæa, xxiii. 507 (1850).

Exsicc. Mabille, Herb. Corsicum, 1868, No. 337, ut *F. speciosa*!

Hæc varietás racemis laxiusculis, pedicellorum tenuiorum bracteis paulo brevioribus, *sepalis* vulgo 4–5 mm. longis 2–3 mm. latis *ovatis* potiusquam ovalibus frequentius subintegris, *corollis primo albidis* sæpius *tandem* omnino *rubris* petalo superiore parum angustato præditis a typo differt.

In addition to the relatively shorter and broader sepals of this variety and its more highly coloured corolla, which often changes wholly from white to deep crimson, the upper petal, when fresh, is distinctly less laterally compressed than in typical *F. capreolata*, and the pedicels seem slenderer and more flexuous, with somewhat shorter bracts.

According to Hammar the racemes are denser than in the type, but the examples examined show laxer racemes as noticed by Jordan ("racemis . . . laxiusculis").

In the living state this variety, which is found chiefly in Spain and Southern France, is especially beautiful owing to the bright red and white colouring of its flowers.

!! Sepala quam typi sæpe longiora; corolla albida vel roseo-tincta.

γ. *albiflora*, Hamm. Mon. Slägt. Fum. 25 (1854), et Mon. 25 (1857). *F. capreolata β. flavescens*, Nicotra, Le Fum. Ital. 44 (1897), excl. syn. partim.

Exsicc. Heldreich, Herb. Græc. Norm. No. 1003, ut *F. capreolata*!

Many North European specimens that have been referred to this variety are probably shade-forms only (forma *parviflora*, Haussk.) of the type, but a few of them and some white-flowered examples from the Mediterranean region appear to constitute a distinct variety.

δ. *Babingtonii*, Pugsley, *l. c.* 9. *F. pallidiflora*, Babington in Journ. Linn. Soc. iv. 157 (1860), non Jordan.

Icon. Journ. Bot. xl. tab. 436, fig. 1, ut *F. capreolata*.

ε. *devoniensis*, Pugsley, *l. c.* 10.

!!! Sepala minora, magis dentata; corolla sæpius rubescens.

ζ. *condensata*, Ball, Spic. Fl. Marocc. in Journ. Linn. Soc. xvi. 315 (1878).

Exsicc. Hooker, Inzuda, Greater Atlas, S. Marocco, 1871, in Hb. Kew!

Racemi densi. Bracteæ pedicellis parum recurvatis paulo breviores. *Sepala* 4 mm. longa, 2·5–3 mm. lata, *ovata*, acuta, basin versus conspicue *inciso-dentata*. Corolla 10–11 mm. longa, ut in var. *speciosâ* rubescens. *Fructûs quam in typo majores*, 2·5 mm. longi et plus 2 mm. lati.

This variety shows the dense racemes characteristic of the specific type combined with relatively small and much cut sepals and large fruits similar to those of var. *Babingtonii*.

η. *Hochreutineri*, var. nov.

Exsicc. B. P. G. Hochreutiner, Voyage botanique en Algérie, 1901, No. 18, Environs d'Alger, ut *F. capreolata* var. *intermedia*, Haussk.!

Sepala relative *parva*, 3–3·5 mm. longa, vix 2 mm. lata, *oblongo-ovata*, breviter acuminata, circumcirca parce serrato-dentata, albida; corolla 10–11 mm. longa, ut in var. *speciosâ* rubescens.

This rare plant, remarkable for its relatively small, toothed sepals, bears a general resemblance in other respects to var. *speciosa*, and in comparison may be regarded as somewhat analogous with the var. *brevisepala* of *F. purpurea*. It agrees in floral characters with Haussknecht's description of his var. *intermedia*, but the plant in the Boissier Herbarium on which this name was founded cannot be retained as a variety of *F. capreolata*, which Dr. Hochreutiner's plant evidently is, and a fresh name for the latter has therefore been substituted.

F. platycalyx, Pomel, Nouv. Mat. Fl. Atlant. 239 (1874), is a plant of which no material has been seen, but it is apparently a shade-form of *F. capreolata*, as treated by Battandier & Trabut (Fl. de l'Algérie, i. 26 (1888)).

Of *F. nemorosa*, Lojacono Pojero in Fl. Sicula, 61 (1888), which is reduced by Nicotra to a synonym of *F. capreolata* var. *albiflora*, several authentic specimens have been seen which either belong to this variety or are shade-forms of the specific type. The diagnosis of *F. nemorosa*, however, states that the fruits are "grosse rugulosis,"—a feature recalling *F. flabellata* rather than any form of *F. capreolata*—and so the name may be held doubtful.

The var. *atrosanguinea*, Brochon & Neyraut, adopted by Rouy & Foucaud (Fl. Fr. i. 171), seems to be a form only of var. *speciosa*, Hammar, in which the sepals as well as the corolla become red. It was originally issued as *F. speciosa*, Jord., forma *atrosanguinea*, in the exsiccata "C. Magnier, Fl. Sel. Exsicc. No. 2388. Pyrénées-Orientales, 1890."

It may be observed that while this variety *atrosanguinea* seems almost inseparable from var. *speciosa*, Hamm., the variety described by Rouy & Foucaud under this latter name appears to be Hammar's type, which is not otherwise accounted for by the collaborateurs.

The variety *provincialis*, Rouy & Foucaud (*l. c.*), seems from the description to be a luxuriant state of *F. capreolata* rather than a true variety—a view borne out by the example in Herb. C. Bailey of "Magnier, Fl. Sel. Exsicc. No. 456," which is cited by the authors in illustration.

Another specimen in the same collection under this name, gathered by Albert in 1893, at Solliès-Toucas, Var, whence Rouy & Foucaud record var. *provincialis*, is, however, much more distinct and perhaps a good variety. This has bracts barely exceeding half the length of the pedicels, and relatively lax and slender racemes of large, pale flowers attaining 14 mm. in length, with the upper petal very narrow and comparatively but very little laterally compressed, much as in var. *speciosa*.

A further conspicuously fine plant allied to this form, but with large fruit, is one from Corfu (Baenitz, Fl. Corcyrensis ; Kastrades, 1896, as *F. capreolata* !), which may likewise be varietally separable.

It is not always easy, in the absence of adequate material and a knowledge of the habitats, to justly estimate the value of the differences presented by this widely distributed and variable species.

With regard to the geographical distribution shown at pp. 10 and 11 of "*Fumaria* in Britain," the correctness of the habitats, Canaries and St. Helena, given both by Hammar and Haussknecht, may be doubted, the plants intended being probably *F. coccinea* and *F. muralis* respectively.

13. FUMARIA DUBIA, sp. nov.

F. capreolata β. intermedia, Haussk. in Flora, lvi. 541 (1873).

Exsicc. Montagnes voisines du Fort L'Empereur, Alger, 1831, Herb. Fauché, No. 1 (in Hb. Boissier)!

Fumaria *F. capreolatæ* habitu foliisque et *pedunculis* longis *racemos densos superantibus. Bracteæ pedicellos fructiferos arcuato-recurvos subæquantes. Sepala circa* 3·5 *mm. longa et* 2 *mm. lata, ovata*, peltata, acuminata, *denticulata*, albida. *Corolla* 10–12 *mm. longa*, omnino *rosea*, ut videtur, aut roseo-albida; *petalo superiore* angusto *acuto alis roseis* carinam haud superantibus prædito; *petalo inferiore marginibus angustissimis erectis* acuto. *Fructûs parvi*, 2·25 mm. longi et 2 mm. lati, *subrotundi*, ad medium latissimi, superne *in apicem subacutum* et inferne in stipitem quam pedicelli apex angustiorem æqualiter *angustati*, juniores plane apiculati, siccitate apicis foveolis parvis distinctis *rugulosi*.

Descriptio secundum exemplar solum imperfectum in Herb. Boissier.

In montibus Algeriæ habitat.

Hæc *Fumaria* quæ ut species nova dubitanter descripta est, per sepala minora denticulata, per petali superioris alas roseas nec purpureas, et præsertim per fructûs subacutos rugulosos a *F. capreolatâ*, ut videtur, specifice differt.

Secundum cl. Haussknecht hujus plantæ fructus rugulosus transitum ad *F. flabellatam* denotat, sed, me judice, et fructus rugulosus subacutus et corolla augusta sine apice purpureo rosea affinitatem cum *F. coccineâ* monstrant.

The specific name *intermedia* having been already appropriated under the genus *Fumaria* (Withering, Arr. ed. 3, iii. 620, t. 29 (1796)) to represent a plant now referred to *Corydalis bulbosa*, DC., the present form has been described as *F. dubia*.

14. FUMARIA PURPUREA, Pugsley in Journ. Bot. xl. 135 & 179 (1902); Fum. in Brit. 12 (1912). *F. Boræi*, Babington in Journ. Linn. Soc. iv. 157 (1860), non Jordan.

Icon. Journ. Bot. xl. tab. 436, fig. 3.

β. brevisepala, Pugsley, Fum. in Brit. 13.

Icon. Pugsley, *l. c.* fig. 1 (Journ. Bot. l. tab. 519).

There is a British specimen of *F. purpurea* in the Herbarium of Dillenius at Oxford, and another still earlier (circa 1700) in the Herb. Dubois. The latter is labelled "*F.* major scandens floribus albis riche saturate purpureo (sic). Omnibus partibus major est F. scandente nostrate. An F. altera Cæsalp.?"

** Series **Macrosepalæ.**

Pedicelli fructiferi suberecti ; fructûs rugosi.

15. FUMARIA MACROSEPALA, Boissier, Elenchus No. 7, 8 (1838) ; Voyage Bot. Espagne, ii. 19 (1839–1845); Hamm. Mon. 36 (1857); Willkomm & Lange, Fl. Hisp. iii. 880 (1880).

Icones. Boissier, Voy. Bot. Espagne, tab. iv.; Hamm. *l. c.* tab. iii.

Exsicc. Willkomm, Iter Hispanicum, 1845, No. 863, Malaga! Lange, Pl. Hisp. 1851–2, Jaen, in Hb. Kew! Huter, Porta & Rigo, Iter Hisp. 1879, No. 518, ut *F. latisepala*!

In this species, which is said to inhabit rocky slopes rather than cultivated ground, the corolla resembles that of *F. capreolata* in its narrowly winged upper petal and its peculiar reddish dorsal suffusion.

F. malacitana, Haussk. & Fritze in Flora, lvi. 548 (1873), although described as closely allied to *F. gaditana*, Haussk., seems rather, judging by the type specimen in Herb. Boissier (Ad sepes prope Malacitanam, R. Fritze, Mai, 1873!), as well as by the diagnostic characters, a form of *F. macrosepala*, as suggested by Willkomm & Lange (*l. c.* 881). Fritze's specimen is a piece of a large, vigorous plant, gathered late and perhaps on cultivated ground, in which the mucronulus of the fruit is obscured.

A plant sent out by Porta & Rigo as *F. macrosepala*, Boiss. var. *malacitana*, Haussk. & Fritze, (Iter IV Hispanicum, 1895, No. 24!) is luxuriant *F. macrosepala*, with the sepals and corolla ranging to 7 mm. and 13 mm. in length respectively.

This fine species is reported also for the mountains of Tetuan, in Morocco, by J. Ball in Journ. Linn. Soc. xvi. 315 (1878). Ball's specimen is at Kew.

16. FUMARIA BERBERICA, sp. nov. (Pl. **11**, fig. 1.)

F. agraria var. *atlantica*, Ball, Spic. Fl. Marocc. in Journ. Linn. Soc. xvi. 316 (1878), non Cosson.

Exsicc. J. Ball, Iter Maroccanum, Aït Mesan, 1871, in Hb. Kew, ut *F. agraria* var. *atlantica*!

Fumaria habitu robusto sine dubio annua. Folia 2–3-pinnatisecta, foliolis in lobos oblongos acutos mucronatosve eis *F. agrariæ* similes fissis. *Racemi* 10–15-flori, *pedunculos subæquantes*. *Bracteæ magnæ*, lineari-lanceolatæ, acuminatæ, subfoliatæ, *pedicellos* fructiferos *suberectos* breviusculos apice multo incrassatos conspicue *superantes*. *Sepala* 4·5–5·5 *mm. longa*, 2·5–3 *mm. lata*, *ovata*, peltata, acuminata, circa basin marginemque inferiorem *parce*

serrato-dentata, præter nervum dorsalem latum viridem albida, corollæ tubo latiora. *Corolla* 11–12 *mm. longa, roseo-albida*; *petalo superiore alis atropurpureis* reflexis carinam æquantibus apicemque fere attingentibus *subacuto*; *petalo inferiore* acuto *marginibus erectis angustissimis*; petalis interioribus apice atropurpureis. *Fructûs majusculi*, circa 2·5 mm. longi ac lati, *subrotundi*, *cum mucronulo* persistente *obtusissimi* et inferne parum angustati, paululum compressi sed distincte carinati, siccitate apicis foveolis parvis obscuris dense sed haud grosse *rugosi*.

Hæc rara species, ad gregem *Capreolatarum* plane referenda, *F. macrosepalæ* proxima est, sed sepalis dentatis, corollis minus angustatis apicem versus haud rubescentibus nec in siccitate viridescentibus, fructibus minoribus sed distinctius rugosis differt.

Quanquam cl. Ball hanc plantam ad *F. agrariæ* varietatem retulit, id ab illo dubitanter factum esse manifestum est, nam "Planta haud omnino certa—facies *F. capreolatæ*, sed characteres potius *F. agrariæ*" scripsit. Ut etiam *F. macrosepalam* certe cognovit ejus similitudinem cum *F. berbericâ* non vidisse paulo notabile est, et per hujus corollam in vivo latiorem forsitan explicandum sit.

F. capreolata per flores angustiores, pedicellos arcuato-recurvos fructûsque læves minores, *F. agraria* per sepala parva, corollam omnino diversam fructûsque rostratos grosse rugosos, et *F. flabellata* per corollæ formam pedicellosque arcuato-recurvos plane distant.

F. berberica in rupibus arenaceis Atlantis majoris Mauritaniæ australis, in convalle Aït Mesan (alt. 1600 m.) habitat.

A second specimen in Herb. Kew (*F. agraria*, var. —, Hooker, Revaia, 6–7000 ft., S. Marocco, Greater Atlas, May, 1871!) may also belong to this species, but it shows no fruit and is too fragmentary for certain determination.

17. Fumaria coccinea, Lowe MSS. in Herb. Kew and Herb. Mus. Brit., sp. nov. (Pl. **12**.)

F. montana, Haussk. in Flora, lvi. 546 (1873), et auct., non Schmidt.

Exsicc. Bourgeau, Pl. Canar. No. 178, ut *F. capreolata*! De la Perraudière, Canaries, 1855, in Hb. Boissier, ut *F. capreolata* var. *canariensis*! Lowe, Santa Cruz, Teneriffe, 1859, in Hb. Mus. Brit.! Bornmüller, Pl. Exsicc. Canar. 1901, No. 2029! et No. 2028 (forma umbrosa), ut *F. montana*! Sprague & Hutchinson, Canary Is., No. 1265!

Fumaria annua, internodis longis *gracilis*, plus minusve ramosa, petiolis cirrhosis scandens. Folia sæpe parvula, foliolis in lobos oblongos, subellipticos vel late cuneatos, sæpissime obtusos et nonnunquam mucronatos fissis, infimis breviter petiolatis, irregulariter 2-(rarius 3-) pinnatisecta. *Racemi pauciflori* (6–12-flori), *pedunculis* gracilibus paulo *breviores*. *Bracteæ* lineari-subulatæ, acuminatæ, *pedicellis* fructiferis *erecto-patentibus*, rectis flexuosisve, apice incrassatis, sæpe breviusculis, paulo *breviores*. *Sepala* 3–4 *mm. longa*, circa

2 *mm. lata, oblongo-ovata* vel oblongo-lanceolata, peltata, acuta, *parce dentata* vel etiam præcipue basin versus paululum laciniata, nervo dorsali obscuro viridiusculo albida vel roseo-albida, corollæ tubum subæquantia, longe persistentia. *Corolla* 8–10 *mm. longa, rubra vel coccinea* (in formis umbrosis albida), in fructu juniore persistens ; *petalo superiore alis rubris angustissimis* (carinam haud æquantibus) *vel* omnino *obsoletis acuto angustissimo*; *petalo inferiore marginibus angustis erectis* apicem haud attingentibus acuto; petalis interioribus prope rectis apice parum saturatioribus. *Fructûs parvi* vel mediocres, 2–2·5 mm. longi ac lati, *subrotundo-quadrati*, obtusissimi *obtusi* vel rarius acutiusculi, inferne abrupte angustati, satis carinato-compressi, siccitate apicis foveolis parvis plus minusve distinctis *rugosi*.

F. coccinea habitu gracili, floribus minoribus rubris angustissimis petalo superiore fere exalato præditis ab hujus seriei aliis speciebus differt.

F. montana, Schmidt in Beit. Fl. Cap. Verd. Inseln, p. 268, quâcum *F. coccineæ* forma umbrosa a cl. Haussknecht auctoribusque recentioribus confusa est, habitu robustiore, foliolis longius petiolatis cum lobis angustioribus, bracteis longissimis, floribus minoribus semper albidis, petali inferioris subspathulati marginibus patentibus fructuque majore subgloboso plane carinato distinguitur et ad subsectionem *Latisepalarum* referenda est.

F. coccinea habitat in insulis Canariensibus ubi in montibus sylvaticis invenitur.

This very distinct fumitory, which has been distributed at intervals from the Canaries under different names, can only be placed among the *Capreolatæ*, and is remarkable for its very narrow and nearly unicolorous corollas. In the living state, when not shade-grown, the flowers appear to be bright red in colour, and have been referred to by collectors as crimson, "coccinea," and "sanguinea."

The fruits of this species show considerable variation in form, for while those of Lowe's original specimens are quite rounded-obtuse, other herbarium material furnishes a transition to the subacute-fruited form lately obtained by Messrs. Sprague & Hutchinson.

Haussknecht's identification of this plant with Schmidt's *F. montana* seems attributable to the similarity in size and colour of the flowers when *F. coccinea* is shade-grown, both species lacking the dark corolla-tip that is generally prevalent in the genus. There is also some resemblance in the sepals, but in other respects the two plants appear widely different.

Subsectio III. **MURALES.**

Murales, Haussk. in Flora, lvi. 513 (1873). *Capreolatæ*, Hamm. Mon. 24 (1857), ut sectio, ex parte ; *Mediæ*, Pugsley, Fum. in Brit. 15 (1912).

Pedunculi plus minusve breviusculi, eis *F. bicoloris* et *F. sepium* exceptis. Pedicelli quam in subsectionibus prioribus sæpius minus incrassati, nisi in *F. Thuretii*. Bracteæ longitudine variabiles sed pedicellos fructiferos raro

æquantes. Flores racemorum recentiorum quam in prioribus sæpe pauciores minusque explicati. Sepala dentata, serrata vel integriuscula, raro corollæ tertiâ parte longiora vel ejus tubo plane latiora. Petala exteriora obtusa vel acuta, inferius marginibus angustis qui apicem vix attingentes plerumque erecti rarius patentes sunt. Fructûs parvi aut modici, formæ diversissimæ, siccitate tuberculato-rugosi, rugulosi vel etiam læves.

In this subsection the wings of the upper petal, as well as the tip of the inner ones, are dark purple except in *F. bicolor* and some forms of *F. Bastardii*.

The term *Mediæ*, which was applied to this difficult group in "*Fumaria* in Britain," has been abandoned in favour of *Murales*, Haussk. as further investigation sufficiently shows that *F. media*, Loiseleur, 'Notice,' p. 101 (1810), a plant whose identity has given rise to much discussion, represents only a rampant form of *F. officinalis*, Linn. and has no connection with the species of this subsection. Loiseleur refers to its retuse fruits in his diagnosis and again in his subsequent remarks, and the figure which he quotes (Vaillant, Bot. Par. tab. x. fig. 4)—an exceptionally good drawing but without fruits—bears a raceme of dorsally compressed flowers, with small sepals, which, if not a form of *F. officinalis*, can only be referred to *F. major*, Bad. De Candolle, Reichenbach, and Boreau clearly regard *F. media*, Lois. as closely allied to *F. officinalis*, and Parlatore (Mon. Fum. p. 59) shows at some length that they are not separable as species, a view more recently maintained in Rouy & Foucaud's 'Flore de France' and Nicotra's 'Le Fumariacee Italiane.' The confusion that has arisen through the connection of this name with *F. muralis* and its allies seems largely due to Hammar's interpretation of *F. media* (Mon. Fum. p. 28), which, combined with his association of *F. Bastardii* with *F. muralis*, forms the most serious error in his generally excellent work, and is carefully corrected by Haussknecht. The further extension of Loiseleur's name by Willkomm & Lange (Fl. Hisp. iii. p. 882) to cover the majority of the varied Spanish forms of this group argues a treatment of this subsection quite unequal to that of the remainder of the genus.

* Series **Sub-Agrariæ.**

Sepala parva; petali inferioris margines angusti, patentes; fructûs rugosi.

18. Fumaria bicolor, Sommier ex Nicotra in Le Fum. Ital. 55 (1897); Fl. Giglio, 7 (1900). *F. capreolata* var. —, Duthie in Journ. Bot. x. 208 (1872); *F. rupestris* var. *maritima*, Battandier in Bull. Soc. Bot. Fr. xxxii. 336 (1885); *F. Loiseleurii* Clavaud *β. leronensis*, Burnat, Fl. Alp. Marit. 69 (1892).

Exsicc. Burnat, St. Marguerite, Cannes, in Hb. Boissier & Hb. Zurich, ut *F. Loiseleurii β. leronensis*! Townsend, St. Marguerite, 1872, in Hb. Kew, ut *F. maculata*! Duthie, Fl. Melit. Exsicc. 1874, in Hb. Kew & Hb. Mus. Brit., ut *F. capreolata*, var. —!

Fumaria annua, *habitu gracili*, diffusa vel petiolis cirrhosis scandens. Folia glaucescentia aut viridia, foliolis in lobos lanceolatos acutos vel oblongos mucronatos fissis irregulariter 2–3-pinnatisecta. *Racemi pauciflori* (8–12-flori), *pedunculis* tenuibus sæpe incurvatis *breviores. Bracteæ* oblongæ, cuspidatæ, *pedicellis* fructiferis gracilibus flexuosis *interdum suberectis interdum patentibus triplo quadruplove breviores. Sepala minima, 2–2·25 mm. longa, circa* 1 *mm. lata, ovalia*, vix peltata, breviter acuminata, *plus minusve dentata*, nervo dorsali rubro rosea, corollæ tubo multo angustiora. *Corolla* 10–13 *mm. longa, fere recta, albida vel roseo-albida, tandem* præter petalorum interiorum apicem omnino *rosea*, ut in racemo singulo flores juniores albidi maturiores rosei videantur; *petalo superiore subacuto alis roseis* reflexis apicem vix attingentibus carinam æquantibus vel paulo excedentibus calcar breviusculum versus longe productis ut in *F. Bastardii*; *petalo inferiore marginibus angustis patentibus* roseis apicem haud attingentibus acuto; petalis interioribus apice atropurpureis. *Fructûs parvi*, 2–2·25 mm. longi et 1·5–1·75 mm. lati, *subrotundo-ovati, subacuti* sed inferne parum angustati, obscure carinati et paululum compressi, siccitate *dense* sed haud grosse *rugosi*, apice *foveolis* angustis *sæpius nigris* et nonnunquam maculâ laterali nigrâ notati.

Hæc species, a cl. Sommier in 'Florula del Giglio' et a cl. Burnat in 'Flore des Alpes Maritimes' bene descripta, in subsectione *Agrariarum*, ad quam per corollæ formam accedit, a cl. Nicotra locata est. In aliis characteribus, sicut in habitu gracili et in fructûs formâ, subsectionem *Muralium* plane refert, et, me judice, *F. Bastardii*, Bor. (et præcipue varietati *vaganti*) proxima est.

F. bicolor racemis paucifloris, pedunculis tenuibus longioribus, bracteis sepalisque minimis, corollâ angustiore fere rectâ, petali superioris calcare breviore, petali inferioris marginibus paulo latioribus, fructibus minoribus et densius rugosis a *F. Bastardii* distinguitur.

F. rupestris, Boiss. habitu robustiore, bracteis longis setaceo-acuminatis, sepalis majoribus lanceolatis, fructibus rugosioribus multo majoribus plane differt.

F. amarysia, Boiss. bracteis multo longioribus, petalis interioribus apice brevius atropurpureis, fructibus multo majoribus obovatis subtruncatis longe recedit.

F. bicolor in insulis italicis Giglio, Elbâ, Montecristo, Capraiâ et Giannutri, atque in insulâ Sta. Margaritâ prope Cannes Galloprovinciæ dumeta nec culta habitat; in insulâ Melitâ etiam in locis saxosis umbrosis atque in scopulis maritimis Algeriæ invenitur. In herbario Kewensi exemplar imperfectum "*F. Petteri* Rchb. Sicilia, Parlatore, No. 137" forsitan ad hanc speciem relatum sit.

This rare fumitory, one of the few species not affecting disturbed ground, is especially interesting to British botanists in that it was discovered in 1872 almost simultaneously at Cannes by the late Mr. F. Townsend, who pointed

it out to M. Burnat, and at Malta by Mr. J. F. Duthie. The identity of *F. bicolor* and *F. Loiseleurii β. leronensis* seems to have been hitherto overlooked.

19. Fumaria Bastardii, Boreau in Duchartre Rev. Bot. ii. 359, excl. var. β (1846–7); Fl. du Centre, ed. 2, 28 (1849), et ed. 3, 34 (1857); Pugsley, Fum. in Brit. 35 (1912). *F. confusa*, Jordan in Cat. Dijon (1848), et Linnæa, xxiii. 469 (1850); Pugsley in Journ. Bot. xl. 173 (1902); *F. media β. confusa*, Hamm. Mon. 28 (1857), non *F. media*, Loiseleur; *F. Gussonei*, Boiss. ex Haussk. in Flora, lvi. 513 (excl. *F. Petteri*, Rchb. in syn.), in sensu lato (1873).

Icones. Hamm. *l.c.* tab. 3, ut *F. media β. confusa*; Journ. Bot. xl. tab. 436, fig. 6, ut *F. confusa*.

Exsicc. Billot, Fl. G. & G., No. 1206! et No. 3307 bis! Schultz, Herb. Norm. No. 605, ut *F. confusa*!

Fumaria annua, habitu satis robusto, sæpe ramosissima, *suberecta vel diffusa* vel rarius petiolis cirrhosis scandens. Folia irregulariter 2–3-pinnatisecta, viridia vel glaucescentia, foliolis in lobos oblongos acutos mucronatosve quam *F. muralis* angustiores fissis prædita. *Racemi laxiusculi, multiflori* (vulgo 15–25-flori), *pedunculos superantes. Bracteæ* lineari-oblongæ, cuspidatæ, *pedicellis fructiferis* longiusculis *suberectis* vel erecto-patentibus *duplo* vel etiam triplo *breviores. Sepala circa* 3 *mm. longa*, 1·5 *mm. lata, ovalia*, vix peltata, acuta, plus minusve circumcirca *serrata*, præter nervum dorsalem viridiusculum rosea, corollæ tubo angustiora, inferne remota, sæpe in fructu juniore persistentia. *Corolla* 10–11 (raro 12) *mm. longa, præter petalorum interiorum apicem atropurpureum rosea*; *petalo superiore* obtuso vel acuto, *a latere compresso* (dorso satis angusto), etiam in gemmis haud spathulato, *alis roseis* reflexis calcar versus longe productis sæpe carinam excedentibus apicemque attingentibus prædito; calcar sepalis longius: *petalo inferiore marginibus angustis patulis* apicem vix attingentibus subacuto. *Fructûs modici*, circa 2·5 mm. longi ac lati, *rotundati, obtusiusculi* vel rarius obtusissimi, paulo compressi sed obscure carinati, in vivo *inferne* in stipitem obscurum qui pedicelli apicem parum incrassatum æquat vel excedit sæpissime *vix angustati*, siccitate apicis foveolis latis paululum obscuris satis *rugosi*.

! Petalum superius omnino roseum.

β. patens, comb. nov.; *F. Gussonei*, var. *patens*, Haussk. *l.c.* 518.

Exsicc. Mabille, Herb. Corsicum, 1868, No. 338, ut *F. Gussonei*!

Planta laxa sed robusta, foliorum lobis quam in typo paulum latioribus. *Bracteæ acuminatæ*, infimæ *pedicellos* fructiferos breviusculos *flexuosos sæpe patulos* subæquantes, reliquæ dimidio breviores. Corolla 9–10 mm. longa. *Fructûs* circa 2 mm. longi ac lati, ut in var. *Gussonei subglobosi* et *leviter rugosi*. Aliter ut in typo.

γ. *vagans*, var. nov.

F. vagans, Jord. in Cat. Grenoble (1849), et Linnæa, xxiii. 508 (1850); Hamm. *l. c.* 46.

Icon. Hamm. *l. c.* tab. 6, ut *F. vagans.*

Bracteæ oblongæ, cuspidatæ, apice denticulatæ, pedicellis fructiferis triplo breviores. Sepala 2–2·5 mm. longa, 1·5–2 mm. lata, rotundato-ovalia, breviter acuta, nervo dorsali incrassato carinata. Petalum superius vix a latere compressum, alis roseis patenti-reflexis carinam paulo superantibus apicemque vix attingentibus subacutum. *Fructûs* circa 2·25 mm. longi, 2 mm. lati, *subrotundo-ovati, acutiusculi,* inferne in stipitem obscurum quam pedicelli apex paulo angustiorem angustati, *tenuiter rugosi.* Aliter ut in typo.

This plant, though near the specific type, is separable by its more carinate sepals, by the form of its corolla, which when fresh is broader and less laterally compressed, and especially by its smaller, more acute and more finely rugose fruits. Rouy & Foucaud's variety *occidentalis* of *F. vagans* (Fl. France, i. p. 174) seems from the description to be a shade-form only.

!! Petalum superius apice atropurpureum.

δ. *Gussonei*, Pugsley, Fum. in Brit. 40 (1912). *F. Gussonei*, Boiss. Diag. Pl. Or. ii. No. 8, p. 13 (1849); Hamm. *l. c.* 34. (Pl. **9**, fig. 3.)

Exsicc. Billot, Fl. G. & G., No. 1109, ut *F. Gussonei*! Fiori &c., Fl. Exsicc. Ital. No. 827, ut *F. serotina* var. *Gussonei*! Lojacono, Pl. Ital. Select. No. 74, ut *F. Gussonei*!

Varietas sæpius satis nana foliis plus minusve glaucis. *Sepala* 2–3 mm. longa, 1–2 mm. lata, *quam typi* paulo *latiora. Corolla* 9–10 (raro 11) mm. longa; *petalo superiore alis atropurpureis* sæpe obtuso; petalo inferiore marginibus quam in typo angustioribus. *Fructûs satis parvi,* circa 2 mm. longi et lati, *subglobosi,* rotundato-obtusi et inferne plane angustati, siccitate quam in typo apicis foveolis obscurioribus *tenuius rugosi.*

ε. *hibernica*, Pugsley, Fum. in Brit. 41 (1912).

Icones. Eng. Bot. Suppl. 2976, ut *F. confusa.* Pugsley, *l. c.* fig. 5 (Journ. Bot. l. tab. 519).

The E.B.S. figure was drawn from a Scilly specimen collected by Townsend. Although not very characteristic, the acuminate purple tip of the upper petal is sufficiently indicated.

The Spanish plant represented in the exsiccata "Sennen, Pl. d'Espagne, No. 228," as *F. vagans,* closely resembles this variety except for its smaller, acuter fruits.

ζ. *affinis*, var. nov.

F. affinis, Hamm. Mon. Slägt. Fum. 47 (1854), et Mon. 39 (1857).

Icon. Hamm. Mon. tab. 5, ut *F. affinis.*

Exsicc. Lange, Almeria, 1852, in Hb. Boiss.!

Hammar's description and figure of this little-known plant recall the small-flowered form of *F. major*, Bad., but Lange's specimen from Almeria in

Herb. Boissier clearly belongs to *F. Bastardii*, as determined by Haussknecht. In the colour of the corolla it resembles var. *Gussonei*, but the flowers are larger with more broadly winged outer petals; and the fruits are relatively large and very obtuse, approaching those of *F. major* in shape but showing no mucronulus in the dry state.

The specimen of *F. affinis* in Herb. Kew, received from Lange, does not agree with that in Herb. Boissier and with Hammar's diagnosis, but seems to be a large-flowered example of typical *F. Bastardii*.

η. *benedicta*, comb. nov.

F. Gussonei var. *benedicta*, Nicotra in Nuov. Giorn. Bot. Ital. nov. ser. iv. 312 (1897); Le Fum. Ital. 53 (1897).

Icon. Nuov. Giorn. Bot. Ital. *l. c.* tab. 10.

This variety is remarkable for the black apical pits and lateral markings of its fruit, resembling those of *F. bicolor*. It is also characterized by its rampant habit, relatively broad leaf-segments, apically thickened pedicels, and rather narrow sepals and wings to the upper petal.

Plants agreeing in all respects with Nicotra's description and plate were collected at Tangier by Rev. J. Roffey in the spring of 1916.

F. Jordanii, Gussone, Enum. Pl. Ins. Inar. (1854), seems from authentic specimens to be a variation of var. *Gussonei* with flowers coloured as in the specific type, and *F. serotina*, Guss. (*l. c.*) is perhaps a shade-form of the same plant. The former is stated to have fruits sometimes spotted at the apex. There is Ischian material of both of these plants in Herb. Kew received from Gussone himself.

F. recognita, Lacroix in Bull. Soc. Bot. France, vi. 551 (1859), described as intermediate between *F. Bastardii* and *F. Boræi*, is represented in Herb. Kew by a specimen received from Lacroix in 1861 which is typical *F. Bastardii*, with finely developed flowers and unusually long sepals. Other material observed under this name shows large, dark-tipped flowers resembling those of var. *affinis*, of which *F. recognita* is made a synonym by Rouy & Foucaud.

F. pia, Nicotra in Att. Acc. Dafnica, Acireale, Ser. 2a, i. 5 (1905), may also belong to this species, but its inadequate diagnosis renders its determination impossible in the absence of authentic specimens.

A form resembling the specific type, but with remarkably small flowers (only about 8 mm. long), was collected at Gibraltar by Major Wolley-Dod in 1913.

F. Bastardii is one of the most difficult species of the genus and is unique among the *Grandifloræ* owing to some of its forms having the inner petals only tipped with purple, while in others this colour pervades also the wings of the upper petal. In fruit, likewise, it is remarkably variable, the rugosity being appreciably finer in the varieties *patens*, *vagans*, and *Gussonei* than in

the type. On the other hand, the general habit, the oval, serrate sepals, and the long-winged corolla are so constant and so marked in the plants brought together by Haussknecht under this species, and it is so evident from Herbarium material that they are largely connected by intermediates, that they cannot with confidence be kept specifically apart.

The distribution of this chiefly Mediterranean species is given at p. 41 of "*Fumaria* in Britain." Of its varieties, *β. patens* was described from Corsica, and *γ. vagans* occurs in Southern France; var. *Gussonei* is common in Italy and the neighbouring islands, and grows also in Algeria, Spain, and Greece, as well as in Britain; var. *hibernica* is exclusively British; var. *affinis* is only certainly known from Spain; and var. *benedicta* has been seen from Sicily, Sardinia, and Morocco.

A hybrid (apparently barren) between this species and *F. muralis* subsp. *Boræi* has been observed in Guernsey.

** Series **Eu-Murales**.

Sepala magnitudinis variabilis; petali inferioris margines angustissimi, erecti vel rarius patentes; fructûs læves vel rugulosi.

20. FUMARIA MUNBYI, Boissier & Reuter, Pugillus, 5 (1852); Haussk. in Flora, lvi. 536 (1873).

Exsicc. Reuter, Oran in suburbio La Mosquée, 1849, in Hb. Boiss.! Boissier & Reuter, Prov. Oran, 1849, in Hb. Boiss., ut *F. flabellata*! G. Munby, Oran, in Hb. Kew, ut *F. capreolata*!

Fumaria *robusta sed laxa*, plus minusve elongata, interdum petiolis cirrhosis scandens. Folia foliolis in lobos anguste oblongos acutos vel ovato-oblongos mucronatos (forma *major*, Haussk.) irregulariter 2–3-pinnatisecta. *Racemi laxiusculi, multi-(20–25-) flori, pedunculos* breviusculos *superantes. Bracteæ* anguste lineari-oblongæ, acuminatæ, *pedicellis* fructiferis 5 mm. longis, tenuibus, flexuosis, *patenti-erectis* vel patentibus tertiâ parte *breviores. Sepala* 2–4 *mm. longa*, 1·5–2·5 *mm. lata, subrotundo-ovata* vel ovata, peltata, breviter acuminata, circumcirca (præsertim ad basin) irregulariter *dentata*, nervo dorsali viridi valde carinata, albida. *Corolla speciosa*, 12–13 *mm. longa* (14 mm. in f. *majore*), *pallide rosea*; *petalo superiore alis atropurpureis* reflexis carinam paulo excedentibus apicemque vix attingentibus *obtusiusculo*, calcare quam sepala longiore prædito; *petalo inferiore marginibus angustis patulis* pallidis apicem vix attingentibus acuto, sæpe libero deflexo; petalis interioribus sursum curvatis apice atropurpureis. *Fructûs minimi*, vix 2 mm. longi ac lati, *subrotundi, subacuti vel obtusi*, circa medium latissimi, paululum compressi et obscure carinati, siccitate apicis foveolis parvis paulo obscuris *sublæves*.

Quod ad formam pertinet, fructus *F. Munbyi* satis variabilis videtur, nam quanquam in exemplaribus Boissieranis subacutus in specimine Herbarii Kewensis rotundato-obtusus est.

Hæc rara species, quæ propter flores magnos cum fructibus minimis conjunctos notabilis videtur, per florum spectabilium racemos longos *F. Martinii* proxima est, sed pedunculis longioribus, bracteis longioribus angustioribusque, sepalis dentatis carinatis, petali inferioris marginibus latioribus, et fructibus minimis plane differt.

F. muralis (sensu lato) racemis brevioribus, sepalis ecarinatis, petalo superiore subspathulato, inferiore sine marginibus patulis, fructibus sæpissime majoribus distinguitur. Præterea, hæc species (sensu stricto) per habitum gracilem et flores minores recedit, dum subspecies *neglecta* bracteas breviores, sepala integriuscula, corollas minores, fructûsque obtusiores magis obovatos habet, atque subspecies *Boræi*, ad quam *F. Munbyi* a cl. Hammar, descriptionem in Boissier, Diag. Pl. Or. Ser. II. i. p. 17 (1853), sequente, relata est, sepalis majoribus, petali superioris calcare breviore, fructibus multo majoribus obovatis obtusissimis facile dignosci potest.

F. apiculata, Lge. habitu minus robusto, pedunculis brevissimis, pedicellis suberectis, floribus minoribus acutioribus, sepalis angustioribus paucidentatis, fructibus apiculo persistente præditis separanda est.

F. Bastardii, Bor. per bracteas breviores, per sepala ovalia serrata, et per fructûs majores rugosos nec sublæves a *F. Munbyi* longe distat.

F. Munbyi provinciam Oran in Algeriâ habitat.

21. Fumaria Martinii, Clavaud in Act. Soc. Linn. Bordeaux, tom. XLII. 5ᵉ série, tom. 2, p. lxix (1888). *F. paradoxa*, Pugsley, Fum. in Brit. 31 & 74 (1912).

Icon. Pugsley, *l.c.* fig. 4 (Journ. Bot. l. tab. 519), ut *F. paradoxa*.

Exsicc. Bourgeau, Pl. d'Espagne, 1863, ut *F. Bastardii*! Magnier, Fl. Select. No. 1075!

Since the publication of this plant as a new species under the name of *F. paradoxa*, it has been found that in 1888 a communication respecting Martin's plant mentioned at page 74 of "*Fumaria* in Britain" was made by Clavaud to the Linnean Society of Bordeaux, as cited above, which defines its salient features and its position in the genus, and may fairly be regarded as a valid publication of the name *F. Martinii*. It is therefore proposed to accept this name, reducing *F. paradoxa* to a synonym.

It curiously happens that Clavaud's communication was due to the plant collected by Martin (C. Magnier, Fl. Selecta, No. 1075) being referred by certain botanists to *F. major*, Badarro, just as occurred at first with the British form (Fum. in Brit., p. 35), and it may thus be of interest to reproduce some of Clavaud's observations.

"J'avais indiqué pour cette dernière plante . . . le nom de *F. Martini*, en prévenant M. Magnier qu'il ne fallait y voir qu'une forme du stirpe *Capreolata* voisine du *F. Boræi*, Jord. et du *F. muralis*, Sond. et qu'elle n'avait rien de commun avec le *F. major*, Bad. . . . M. Magnier n'en conserva pas moins sur ses étiquettes le nom de *F. major*, Bad., en m'informant qu'il s'appuyait sur l'opinion de deux éminents botanistes . . . après . . . il m'a adressé une étiquette imprimée conforme à ma détermination . . . chacun peut voir et lire dans la Monographie d'Olof Hammar quels sont les caractères distinctifs très nets des *F. capreolatæ* et des *F. agrariæ* . . . Je me plais à croire que les botanistes un peu au courant du genre *Fumaria* n'auront pas de peine à reconnaître que la plante de M. Martin appartient au groupe du *F. capreolata* et n'a rien de commun avec le *F. major*, Bad. . . . Notre plante n'a d'analogie réelle qu'avec le *F. Boræi*, Jord., *muralis*, Sond. et *speciosa*, Jord., et j'ajoute qu'elle se distingue de ces trois dernières formes elles-mêmes par plusieurs caractères. . . . En somme, si, comme croyaient Koch et Sonder, la terminaison ogivale du fruit a une sérieuse importance, c'est du *F. muralis* que notre plante se rapproche le plus, malgré la dimension très différente de ses fleurs. Si, au contraire, ce caractère de l'achaîne n'était guère ici qu'un accident, comme il se pourrait, notre plante se séparerait bien peu du *F. Boræi*, Jord."

It will thus be seen that Clavaud was the first to notice and to describe the true affinities of this fumitory, and that the restoration of his name, *F. Martinii*, is clearly due to him. In emphasizing its likeness to *F. muralis* and *F. Boræi*, however, he scarcely allows sufficient importance to the long, lax, short-peduncled racemes that lend it the general facies of *F. major*.

Rouy (Fl. France, i. 172) refers Martin's plant to *F. flabellata*, Gasp.—a species lacking even the superficial resemblance that connects it with *F. major*.

When growing, *F. Martinii* is a remarkably beautiful plant owing to its long and graceful racemes and its brilliantly coloured flowers.

It is evidently distributed through the Iberian Peninsula, whence its range extends through Western France to Southern Britain. Its Spanish localities at present known are Navalmoral, Estremadura (Bourgeau, 1863, as *F. Bastardii*!), Calatayud, Aragon (Vicioso, 1906, as *F. affinis*!), Ameyugo, Ayelas, Pancorbo, Castile (Sennen, 1906, as *F. muralis* var. *Paui*!), and Almeria, Andalusia (Huter, Porta & Rigo, 1879, as *F. muralis*!). In Portugal it occurs at Vimioso, Pinello (Mariz, 1888, as *F. agraria*!), and probably in other localities, where it has been confused with *F. muralis* subsp. *Boræi*. The only French stations known are Romorantin, Loir-et-Cher (Martin, 1884 !), Gatteville, Manche (Tardieu, 1880, as *F. Boræi*!) and Rennes, Bretagne (Hb. Kew, as *F. capreolata*!). In Britain, in addition to Penryn, Cornwall (Davey, 1904 !), it grows in the island of Guernsey (Pugsley, 1914 !).

22. Fumaria sepium, Boissier, Diag. Pl. Or. Ser. ii. No. 1, p. 16 (1853); Hamm. Mon. 27 (1857); Haussk. in Flora, lvi. 525 (1873). *F. muralis* var. *platycarpa*, Rouy & Foucaud, Fl. Fr. i. 173 (1893). (Pl. **9**, figs. 8, 9.)

Exsicc. Boiss. & Reuter, Algeciras, 1849, in Hb. Boiss.! Wolley-Dod, Fl. Calpensis (Algeciras), Nos. 1711! et 201!

Fumaria annua, *robusta*, ramosa, elongata, sæpe petiolis cirrhosis longe lateque *scandens*. Folia irregulariter 2–3-pinnatisecta, foliolis in lobos oblongos, cuneatos vel ovato-rotundos plus minusve obtusos et sæpius longiuscule mucronatos fissis prædita. *Racemi laxiusculi, pauciflori* (6–12-flori), *pedunculis* gracilibus vulgo strictis rarius paulo incurvatis *breviores*. *Bracteæ* anguste lineari-lanceolatæ, setaceo-acuminatæ, *pedicellos* fructiferos 5 mm. longos, tenuissimos, *erecto-patentes*, strictos vel flexuosos *infimæ subæquantes*, ceteræ breviores. *Sepala* 4–5 *mm. longa*, 2–2·5 *mm. lata*, *ovata* (in formis umbrosis angustiora, lanceolata), peltata, plus minusve acuminata, basi parce dentata aliter *subintegra*, præter nervum dorsalem viridem albida, corollæ tubo æquilata. *Corolla magna*, 12–14 *mm. longa*, *speciosa*, *roseo-albida*, præsertim apicem versus læte rubescens (in floribus serioribus pallida et interdum conspicue minor); *petalo superiore subacuto*, vix dorsum compresso, calcare longo deflexo *alis*que intense *atropurpureis* reflexis carinam paulo excedentibus sed apicem vix attingentibus prædito; *petalo inferiore marginibus angustissimis erectis vel subpatentibus* apicem haud attingentibus acuto, sæpe libero deflexo; petalis interioribus albidis vel rubescentibus apice atropurpureis. *Fructûs parvi*, circa 2 mm. longi ac lati, *subrotundi*, *obtusissimi*, subcompressi, carinati, in vivo inferne in stipitem paulo obscurum quam pedicelli apex paulisper angustiorem contracti, siccitate *læves* apicis foveolis parvis notati.

Descriptio secundum exemplaria viva ad Algeciras (in loco classico) a Major Wolley-Dod collecta, Martio, 1913.

β. gaditana, var. nov.

F. gaditana, Haussk. *l. c.* 547; Willkomm & Lange, Fl. Hisp. iii. 879 (1880).

Exsicc. Boissier & Reuter, Tangier, 1849, in Hb. Boiss.! Boissier & Reuter, Grazalema, Prov. Granada, 1849, in Hb. Boiss.! Wolley-Dod, Fl. Calpensis, Nos. 1629! 1647! 1701!

Racemi densiores, vulgo 10–16-flori; pedunculi pedicellique robustiores. *Bracteæ quam in typo breviores* latioresque, lineari-oblongæ, acuminatæ, pedicellorum longitudinem dimidiam paulo superantes. *Sepala* 3–4 mm. longa, 1·5–2 mm. lata, *oblongo-ovata*, acuta, saltem basin versus parce irregulariter *dentata*. Corolla typi sed tandem sæpe omnino rubescens. *Fructûs quam in typo majores*, 2·5 mm. longi ac lati, subrotundo-quadrati.

Hæc pulchra species, cujus primum forma umbrosa floribus depauperatis a cl. Boissier et a cl. Hammar descripta est, nunc e plantâ normali depingitur. Inter *F. capreolatam* et *F. muralem* medium fere tenet, sed ab alterâ racemis

paucifloris, pedicellis tenuibus nec recurvatis, sepalis minoribus, sine stipite distincto fructibus, ab alterâ foliorum segmentis latioribus, pedunculis longioribus, sepalis subintegris, corollis angustioribus albidis nec roseis plane differt.

F. macrosepala et *F. berberica* subsectionis *Capreolatarum* pedicellis crassioribus, bracteis sepalisque majoribus, fructibus majoribus rugosis nec lævibus facile separandæ sunt.

Speciei typus hactenus in Algeciras Bæticæ solum inventus est, sed varietas *gaditana* freti Gaditani contrarias partes in Bæticâ et in Mauritaniâ habitat. Exemplar nunc in herbario Mus. Brit. a cl. R. P. Murray ad sepes prope Cintram Lusitaniæ collectum ad hanc speciem, ut videtur, etiam referendum est.

This fine but local fumitory was originally described by Boissier from a depauperate form, collected at Algeciras late in the season, in which, as sometimes happens with other species, the sepals were particularly narrow. The flowers of this material were so poor that its identity with other specimens obtained the same year by Boissier & Reuter at Tangier, Grazalema, and Gibraltar does not appear to have been recognized by Boissier or later by Haussknecht, although the Tangier example in Herb. Boissier is labelled *F. sepium* in the handwriting of Reuter.

These last-named plants, as represented in Herb. Boissier, are more or less normal, though collected late, and form the basis of Haussknecht's *F. gaditana*, which he seems to have regarded as in no way related to the *F. sepium* from Algeciras. But it is clear that the original *F. sepium* is a depauperate shade-form, and its specific identity with *F. gaditana*, first suggested by Willkomm & Lange (*l.c.*), may be confirmed by a comparison with "Porta & Rigo, Iter IV Hisp. 1895, No. 610" from Algeciras and the specimens collected in 1913 by Major Wolley-Dod in Boissier's original locality, some of which are shade-forms plainly showing a transition to the state of the plant as found by Boissier. As Boissier's name antedates *F. gaditana*, it must necessarily stand for the species, and as the plant of Algeciras, which is thus the specific type, seems to differ in minor details from that found at Gibraltar and elsewhere, this latter form has been distinguished as a separate variety *gaditana*.

23. Fumaria muralis, Sonder in litt. ap. Koch, Synopsis Fl. Germ. ed. 2, Appx. 1017 (1845); Haussk. in Flora, lvi. 523 (1873); Pugsley in Journ. Bot. xl. 175 (1902), et Fum. in Brit. 16, 22 & 74, excl. *F. apiculata* in syn. (1912). *F. capreolata β. Burchellii*, DC. Syst. ii. 133 (1821); *F. media γ. muralis*, Hamm. Mon. 29 (1857), non *F. media*, Lois.

Icones. Fl. Danica, tab. 2473; Hamm. *l.c.* tab. 4, ut *F. media γ. muralis* (fructu obtuso); Journ. Bot. xl. tab. 436, fig. 4.

Exsicc. Billot, Fl. G. & G. No. 2807! Mandon, Pl. Mader. No. 5! Bourgeau, Pl. Canar. No. 1173, ut *F. officinalis*!

Fumaria annua, *habitu* semper *gracili* et sæpius exiguo, interdum in arvis nana, suberecta, ramosior, interdum diffusa vel petiolis cirrhosis scandens. Folia irregulariter 2–3-pinnatisecta, nonnunquam plus minusve glauca, foliolis (sæpius parvis) in lobos oblongos mucronatos vel lanceolatos acutos fissis. *Racemi laxiusculi, pauciflori* (sæpissime sub-12-flori), *pedunculos* graciles rectos incurvatosve *fere æquantes. Bracteæ* lineari-lanceolatæ, acuminatæ, *pedicellis* fructiferis tenuibus qui plerumque recti et *erecto-patentes* sed rarius flexuosi et paulo recurvati sunt *tertiâ parte breviores. Sepala 3–4 mm. longa,* 1·5–2 *mm. lata, ovata,* peltata, sæpissime acuminata, præsertim basin versus et in margine inferiore plus minusve *dentata*, præter nervum dorsalem viridiusculum albida vel roseo-albida, latitudine corollæ tubum æquantia. *Corolla* 9–10 *mm. longa, rosea; petalo superiore* dorsum compressiusculo, haud lato, *alis atropurpureis* reflexis carinam superantibus apicemque fere attingentibus *apiculato* et, ut in floribus junioribus saltem videtur, spathulato; calcare sepala fere æquante; *petalo inferiore marginibus erectis* angustissimis acuto vel apiculato; petalis interioribus sursum curvatis apice atropurpureis. *Fructûs parvi* vel etiam minimi, circa 2 mm. longi (apiculo incluso) et latitudine paulo minores, *subrotundo-ovati* vel subrotundi, usque ad maturitatem *acutiusculi vel obtusi* brevissime *apiculati*, in stipitem prope obsoletum inferne angustati, parum compressi et obscure carinati, in sicco apicis foveolis parvis sæpius paululum obscuris *læves.*

! Fructûs subglobosi sine apiculo obtusi.

β. *læta*, Lowe, Fl. Mader. i. 15 (1868).

Herba virescens, foliorum segmentis latiusculis, racemis 8–15-floris, *sepalis subintegris, corollis usque ad* 12 *mm. longis, læte roseis* apice atropurpureis, *fructibus* obtusis *subglobosis* obsolete *rugulosis.*

Lowe's types of this Madeira variety, notable for its large, bright flowers with almost entire sepals, are in Herb. Mus. Brit.

[γ. *Lebelii*, Rouy & Foucaud, Fl. Fr. i. 173 (1893); non vidi.

This plant appears to be chiefly notable for its dense racemes and broad bracts and sepals.]

δ. *Lowei*, Pugsley, Fum. in Brit. 17 & 23 (1912).

In addition to the points of distinction already assigned to this variety, its sepals are commonly broader and less acuminate than in the specific type.

Lowe's specimens referable to this variety are in Herb. Mus. Brit.

! ! Fructûs subrotundo-ovati, acutiusculi vel brevissime apiculati.

ε. *decipiens*, Pugsley, Fum. in Brit. 23 (1912).

F. Boræi δ. *muraliformis*, Clavaud, Fl. Gironde, p. 49 and Pl. iii. B 2 (1882), appears from authentic material to be a form of *F. muralis* closely allied to var. *Lowei*, and his *β. verna* and *γ. serotina* early and late states of the same form.

The present remarkable distribution of *F. muralis* is shown at pages 23 & 74 of "*Fumaria* in Britain." Another link in the chain of habitats extending from north-western Europe and the Atlantic Islands round South Africa to the East Indies and New Zealand is supplied by a specimen in Herb. Mus. Brit. (erroneously referred to *F. parviflora*, Lam.) from Utakamand, in the Nilghiris of Southern India.

The variety *decipiens* occurs in Western France (Reverchon, Roche-sur-Yon, Vendée, 1882, as *F. Boræi*!) as well as in Britain.

23*a*. Subspecies NEGLECTA, Pugsley, Fum. in Brit. 20 & 24 (1912).
Icon. Pugsley, *l.c.* fig. 2 (Journ. Bot. l. tab. 519).

23*b*. Subspecies BORÆI, Pugsley in Journ. Bot. xl. 132, 175 & 180 (1902); Fum. in Brit. 18 & 25 (1912). *F. Boræi*, Jordan in Cat. Grenoble (1849), et Pugillus, 4 (1852); Haussk. in Flora, lvi. 520 (1873); *F. Bastardii β. major*, Boreau in Duchartre, Rev. Bot. ii. 359 (1846–7); *F. media α. typica*, Hamm. Mon. 28, excl. syn. partim (1857), non *F. media*, Lois. (Pl. **9**, fig. 10.)

Icones. Curtis, Fl. Londinensis, ii. tab. 145 (fasc. vi. 47), ut *F. capreolata*; Smith, Eng. Bot. 943, ut *F. capreolata*; Hamm. *l.c.* tab. 3, ut *F. media α. typica*; Journ. Bot. xl. tab. 436, fig. 5.

Exsicc. Billot, Fl. G. & G. Nos. 2209 et 2209 bis, ut *F. Boræi*! Schultz, Herb. Norm. No. 1007, ut *F. Boræi*!

Fumaria sæpius *robusta* et satis ramosa, in arvis suberecta vel plus minusve diffusa, in sepibus murisque elongata et sæpe petiolis cirrhosis valde scandens. Folia irregulariter 2–3-pinnatisecta, viridia (raro plus minusve glauca), foliolis in lobos oblongos vel late cuneiformes, acutos vel mucronatos fissis. *Racemi laxiusculi, haud multiflori* (sub-15-flori), *pedunculos subæquantes. Bracteæ* lineari-lanceolatæ, acuminatæ, *pedicellis* paululum crassis *rectis erecto-patentibus* (aliquanto *flexuosis vel recurvatis* in formis umbrosis) *paulo* (interdum tertiâ parte) *breviores. Sepala* 4–5 *mm. longa*, 2·5–3 *mm. lata*, *ovata* vel subrotundo-ovata, peltata, acuta vel breviter acuminata, sæpissime basin versus *irregulariter dentata* sed raro subintegra, præter nervum viridiusculum albida vel roseo-albida, corollæ tubo latiora et inferne contigua. *Corolla* 10–12 *mm. longa, rosea* vel raro rubra (forma *rubens*); *petalo superiore lato*, dorsum compresso, *alis atropurpureis* reflexis carinam superantibus apicemque sæpe attingentibus *acuto, apiculato vel etiam obtuso*, in gemmis ante alarum reflexionem spathulato, calcare sepalis breviore; *petalo inferiore marginibus* angustissimis *erectis* rarissime patulis acuto, sæpe

libero deflexo; petalis interioribus sursum curvatis apice atropurpureis. *Fructûs modici*, circa 2·5 mm. longi, 2–2·25 mm. lati, *obovati* vel subrotundo-obovati, *obtusissimi*, paulo compressi sed obscure carinati, et in stipitem obscurum quam pedicelli apex haud latiorem inferne angustati, siccitate apicis foveolis parvis distinctis *læves aut leviter rugulosi*.

! Flores fere typi; fructûs subquadrati, rugulosi.

β. *ambigua*, Pugsley in Journ. Bot. xl. 178 & 180 (1902); Fum. in Brit. 26 (1912).

Varietas typi habitu sed foliorum lobis angustioribus lanceolatis, sepalis angustioribus acuminatis, corollis paulo minoribus. *Fructûs* fere 2·5 mm. longi, latitudine paulisper minores, *subquadrati* et *inferne* in stipitem pedicelli apicem saltem æquantem *vix angustati*, quam in *F. Boræi* aliis formis *magis compressi*, in sicco apicis foveolis obscuris leviter rugulosi.

γ. *hispanica*, var. nov.

Exsicc. Porta & Rigo, Iter II Hisp. 1890, No. 105, Almeria, Barranco del Caballar, ut *F. media*, var. *muralis*!

Varietas *bracteis lanceolatis* acuminatis *pedicellos* patulos patenti-recurvosve *æquantibus* vel infimis paulo superantibus; *fructibus* 2·25 mm. longis, 2 mm. latis, subrotundo-quadratis, obtusissimis, inferne paululum angustatis, plane *rugulosis*. Aliter ut in typo.

This plant is remarkable among the forms of the subspecies *Boræi* for its large, broad bracts and distinctly rugulose fruits.

!! Flores minores; fructûs subrotundo-obovati, fere læves; plantæ graciliores.

δ. *gracilis*, Pugsley, Fum. in Brit. 19 & 26 (1912).

ε. *britannica*, Pugsley, Fum. in Brit. 19 & 27 (1912).

Exsicc. Marshall, No. 2915, ut *F. Boræi* var. *serotina*!

ζ. *longibracteata*, Pugsley, Fum. in Brit. 19 & 27 (1912), ut subvarietas.

Hybrids between this subspecies and *F. officinalis*, quite barren and intermediate in characters, have been observed in Guernsey and in the south of England.

The subspecies *Boræi* is a rare plant except in the British Islands and the north and west of France, but there are specimens from Hesse, Germany, and from Sweden in Herb. C. Bailey, and one from Norway in Herb. Kew. Coutinho records it for Portugal, and it occurs in Spain, where it is reported by Haussknecht to grow commonly about Gibraltar and elsewhere in Southern Andalusia. As Major Wolley-Dod, however, recently failed to find it in that district, and met with *F. sepium* in abundance, it is probable that these two plants have been confused.

The records for Morocco and Algeria, though supported by the authority both of Hammar and Haussknecht, may also be doubted, the plants observed in these two countries being probably *F. sepium* and *F. Munbyi* respectively. Hammar's records for the Canaries and South Africa doubtless refer to true *F. muralis*, to which likewise (perhaps var. *læta*) Haussknecht's Madeira locality in all probability belongs. The recognition of the subspecies *Boræi* and of *F. muralis* as Italian plants by Nicotra (Le Fumar. Ital.) seems due to confusion with forms of *F. Bastardii*.

× FUMARIA PAINTERI, Pugsley, Fum. in Brit. 29 (1912).

Icon. Pugsley *l.c.* fig. 3 (Journ. Bot. l. tab. 519).

Although of presumably hybrid origin (*F. muralis* subsp. *Boræi* × *F. officinalis*?) this plant appears to merit recognition as a more or less established form, differing from other known *Fumaria*-hybrids in its general development of perfect fruits.

24. FUMARIA APICULATA, Lange, Ind. Sem. Haun. 23, et Ann. Sci. Nat. Ser. IV. ii. 371 (1854); Hamm. Mon. Slägt. Fum. 36 (1854), et Mon. 31 (1857). *F. Reuteri*, Boiss. Diag. Pl. Or. ii. No. 8, p. 13 (1849), et Pugillus, 4 (1852), ex parte; Haussk. in Flora, lvi. 538 (1873); *F. media* δ. *apiculata*, Willkomm & Lange, Fl. Hisp. iii. 882 (1880), non *F. media*, Lois.

Icon. Hamm. *l.c.* tab. 4.

Exsicc. Lange, Escorial, 1851, in Hb. Boiss.! Reuter, Castella prope Miraflores ad radices Sierræ de Guadarrama, in Hb. Boiss., ut *F. Reuteri*! Durieu, Pl. Sel. Hispano-Lusit. Sec. 1, Asturicæ, 1835, No. 413, Cangas de Tineo, ut *F. capreolata*! Lange, Cordoba ad sepes, 1852, in Hb. Kew, ut *F. Boræi*!

Hæc species hispanica, quæ a cl. Hammar cum icone bene descripta est, quanquam cum *F. Reuteri* confusa, sine dubio *F. muralem* (sensu stricto) maxime refert. A *F. murali* foliorum lobis angustioribus, racemis brevissime pedunculatis, pedicellis fere erectis nec erecto-patentibus, sepalis angustioribus ovato-lanceolatis paucidentatis, petalo superiore angustato acuto, fructibus longioribus cum apiculo minimo persistente obtusiusculis separari potest.

F. Reuteri, planta Granatensis quæ ad *F. Thuretii*, Boiss. a cl. Haussknecht translata est, foliorum laciniis etiam angustioribus, pedicellis patentibus, sepalis late oblongis, corollis minoribus (raro 10 mm. longis), fructibus minimis subacutis stipitatis plane differt.

The closely cohering petals mentioned in Hammar's diagnosis are characteristic of weak or shade-grown plants in this as in other species. In good flowers the lower petal of *F. apiculata* is deflexed and free, as is well shown in the Durieu example in Herb. Kew.

This fumitory has been the subject of considerable confusion. It was first included in 1849 in the original account of *F. Reuteri*, a species founded by Boissier on two Spanish plants, one from Castile and the other from the Sierra Nevada in Andalusia. Five years later a second species, also founded on a Castilian plant, was established by Lange as *F. apiculata*. In Hammar's Monograph these two species are retained, the description of *F. Reuteri* being taken from Boissier's original diagnosis and a specimen, probably Andalusian, sent by him to Fries, while *F. apiculata* is described and figured from living, cultivated plants presumably grown from seed obtained from Lange. Haussknecht, who examined the original material of these plants in Herb. Boissier, detected that the two Spanish examples cited for *F. Reuteri* were essentially different, and retained Boissier's name for the Castilian plant, referring the Andalusian one to the Greek *F. Thuretii*, which it closely resembles. At the same time he made *F. apiculata*, Lge., of which Herb. Boissier also contains an original specimen, a synonym of *F. muralis*, Sond. This arrangement is reflected in Willkomm & Lange's 'Flora Hispanica' (except that *F. apiculata* there becomes *F. media* δ. *apiculata*), but the authors do not appear familiar with the Castilian form placed under *F. Reuteri* or with Boissier's Andalusian plant.

It is evident from the types in Herb. Boissier that Haussknecht correctly separated the two plants on which *F. Reuteri* was founded by Boissier. But the original specimens also show with nearly equal certainty that the Castilian *F. Reuteri* is conspecific with *F. apiculata*, Lge., described from the same district, and th t these two plants, while allied to *F. muralis*, are distinct from it and from all other described forms. They agree well with Hammar's diagnosis of *F. apiculata*, except that the fruiting pedicels are markedly suberect, as noted by Lange, instead of "erecto-patentes," and the fruit perhaps less oval than ovate.

The nomenclature of these plants is involved, for of the two forms originally included by Boissier under *F. Reuteri*, that inhabiting Andalusia is apparently described under this name by Hammar, while Haussknecht restricts the name to the Castilian form. It is clear that this latter plant was the first to be segregated (as *F. apiculata*, Lange), and hence it seems preferable to apply Boissier's name to the Andalusian form and to maintain *F. apiculata*, Lange, for that discovered in Castile. Moreover, although both plants were originally cited for *F. Reuteri* by Boissier, it is probable from the terms of his diagnosis that it was actually taken from the Andalusian one which he himself collected, rather than from the Castilian plant gathered by Reuter which he united with it.

25. FUMARIA PETTERI, Reichenbach, Icones Fl. Germ. iii. 1 (1838); Parlatore, Mon. Fum. 85 (1844), ex parte; Visiani, Fl. Dalmatica, iii. 98 (1852), et Suppl. i. 118 (1872); Hamm. Mon. 32 (1857), ex parte; Schlosser & Vukot. Fl. Croatica, 205 (1869).

Icon. Reichb. *l. c.* tab. 2, fig. 4453 *b.*

Exsicc. Pichler, Mte. Marian bei Spalato, 1885, in Hb. Zurich and Hb. C. Bailey! Huter, Fl. Exsicc. Austro-Hungarica, No. 2900, cult., orig. Clissa in insulâ Lesinâ!

Fumaria annua, *gracilescens,* multo ramosa, diffusa, vix scandens. Folia irregulariter 2–3-pinnatisecta, foliolis flabellatis longiuscule petiolatis in lobos sæpissime oblongos mucronatos fissis. *Racemi laxiusculi, haud multiflori* (vulgo sub-12-, raro ad 18-flori), brevissime pedunculati aut subsessiles. *Bracteæ* lineari-lanceolatæ, acuminatæ, albidæ, *pedicellos* fructiferos apice incrassatos *patulos vel erecto-patentes* (rarius paulo recurvos) *subæquantes. Sepala* 3·5–4·5 *mm. longa,* 2–2·5 *mm. lata, ovalia vel subrhombea,* conspicue peltata, subacuta, præsertim medium versus irregulariter uni- vel *paucidentata,* rarius integriuscula, nervo dorsali viridi sæpe lato albida, corollæ tubo paululum latiora. *Corolla* 9–10·5 *mm. longa, rosea; petalo superiore angustato subacuto alis atropurpureis* reflexis apicem raro attingentibus carinamque viridem abrupte terminatam vix æquantibus et calcare longo adscendente prædito; *petalo inferiore marginibus angustissimis erectis* subacuto; petalis interioribus fere rectis apice atropurpureis. *Fructûs mediocres,* 2·5–2·75 mm. longi et 2 mm. lati, *ovati* vel fere turbinei, plus minusve *apice attenuati, acutiusculi,* prope basin latissimi et in stipitem obscurum quam pedicelli apex angustiorem abrupte angustati, carinati et paulo compressi, siccitate apicis foveolis angustis satis distinctis *rugulosi.*

Hæc species racemis fere subsessilibus, sepalis subrhombeis, corollâ anguste alatâ, fructibus ovatis fere turbineis plus minusve attenuatis acutiusculis inter affines notabilis est.

Apud cl. Boissier in 'Flora Orientalis,' i. 137 (1867), specimina *F. Petteri* dalmatica a cl. Petter accepta *F. Gussonei,* Boiss. affines vel formæ sunt, sed hæc planta, quæ vero *Fumariæ Bastardii,* Bor. solum varietas est, racemis plane pedunculatis, sepalis serratis multo minoribus, petalo superiore latius alato, petali inferioris marginibus patulis, fructibus subrotundis obtusis longe distat.

A *F. murali,* Sond., quæ in Koch, Synopsis Fl. Germanicæ, ed. 2, p. 435, ad hanc speciem relata est, *F. Petteri* racemis subsessilibus, sepalis subrhombeis paucidentatis, petalo superiore angustius alato, fructibus ovatis attenuatis plane separatur.

Racemi laxi floribus magnis multiflori et fructûs qui quidem acutiusculi sed subrotundi nec ovati sunt etiam *Fumariam Martinii,* Clav. sejungunt.

F. Munbyi, Boiss. racemis multifloris longius pedunculatis, sepalis magis dentatis, corollis majoribus cum inferioris petali marginibus patulis, fructibus subrotundis duplo minoribus facile distinguitur.

F. apiculata, Lge. pedicellis suberectis, sepalis ovato-lanceolatis, petalo superiore acutiore sed alis latioribus prædito, fructibus apiculatis lævibus cum hac specie confundi non potest.

In exemplaribus Fl. Exsicc. Austro-Hungarica, No. 2900I, flores fructûsque, ut in fumariis cultis expectandum est, minores sunt quam in speciminibus agrestibus quæ cl. Th. Pichler in vineis ad montem Marian prope Spalato collegit.

F. Petteri montem Marian prope Spalato, insulæ Lesinæ Clissam et forsan locos alios in Dalmatiâ habitat.

The application of the name *F. Petteri*, Rchb. to this apparently rare Dalmatian plant has been decided on only after careful consideration. Although it appears from Hammar's note (Mon. p. 33) that Petter sent out various fumitories under this name, it seems fairly certain that the Dalmatian plant on which Reichenbach founded his species was that cited in Visiani's Fl. Dalmatica, viz.:—"*F. media*, Petter, Bot. Wegw. No. 421, non Lois." (1832), which was collected by Petter at Spalato. Hammar regards this plant as conspecific with *F. Thuretii*, Boiss., but Boissier (*l. c.* supra) entirely dissents from this view, regarding *F. Petteri*, Rchb. as allied rather with *F. Gussonei*. Haussknecht reduces *F. Petteri*, Rchb. to a synonym of *F. Gussonei*, and Halácsy (Fl. Græc. i. 48 (1901)) uses the name in preference to *F. Gussonei* for Boissier's plant. Koch again likened *F. Petteri*, Rchb. to *F. muralis*, which he first referred to it (*l. c.*, supra).

An explanation of these differing views is afforded by the later Spalato specimens collected by T. Pichler and referred to *F. Petteri*, Rchb., which agree with Reichenbach's account, taken in conjunction with the diagnoses in the Floras of Dalmatia and Croatia, and are no doubt identical with Petter's original plant described by Reichenbach. It may be seen from these specimens that while the species produces flowers resembling those of *F. Thuretii* and similarly borne in subsessile racemes, thus accounting for Hammar's union of the two forms, its habit and foliage are very different and rather recall *F. muralis* and *F. Gussonei*, as was noticed by Koch and Boissier respectively. The ovate, attenuate form of the fruit in *F. Petteri*, moreover, is distinctly different from that obtaining in either of these allied plants, and hence there seems sufficient reason for maintaining it as a separate species.

Hammar's figure of *F. Petteri* (Mon., tab. iv.) seems compounded of this and the following species, the foliage and corolla recalling *F. Petteri*, and the pedicel, sepal and fruit *F. Thuretii*.

*** Series **Sub-Latisepalæ.**

Sepala majuscula; petali inferioris margines angustissimi, erecti aut rarius subpatentes obscure apice dilatati; fructûs minimi, plus minusve rugulosi; foliorum laciniæ relative angustæ; flores minores in racemis subsessilibus.

26. Fumaria Thuretii, Boissier, Diag. Pl. Or. Ser. ii. No. 1, p. 15 (1853); Fl. Orient. i. 137 (1867); Haussk. in Flora, lvi. 494 (1873), excl. loc.

hisp.; Halácsy, Fl. Græc. i. 46 (1901). *F. Petteri*, Hamm. Mon. 32 (1857), ex parte, non Reichb.

Exsicc. Heldreich, Herb. Græc. Norm. No. 1005 !

Fumaria annua, habitu *satis robusto*, basi præcipue ramosa, nunc suberecta et sæpe nana nunc in formis umbrosis diffusa subscandens. Folia irregulariter 2–3-pinnatisecta, glaucescentia, foliolis (sæpius parvis) in lobos oblongos mucronatos vel lineari-oblongos acutos fissis. *Racemi sæpius multi*-(15–35-) *flori*, sub anthesin densi, *tandem elongati, brevissime pedunculati* vel subsessiles. *Bracteæ* sublanceolatæ, acuminatæ, *pedicellos* fructiferos breviusculos apice incrassatos, ut in *F. capreolatâ arcuato-recurvos* (in formis umbrosis vulgo rectos divaricatos), *subæquantes. Sepala* 2·5–3 *mm. longa*, 1·5–2 *mm. lata*, *ovata* vel rarius subrhombea, peltata, acuta, parce irregulariter *repando-dentata*, præter nervum dorsalem viridiusculum albida vel subrosea, corollæ tubum subæquantia. *Corolla circa* 9 *mm. longa, intense rosea*, ei *F. Petteri* subsimilis: *petalo superiore angustato subacuto alis atropurpureis* reflexis apicem raro attingentibus carinamque viridem subtruncatam vix æquantibus et calcare adscendente prædito; *petalo inferiore marginibus* angustissimis *erectis* acuto; petalis interioribus apice atropurpureis. *Fructûs minimi*, circa 2 mm. longi ac 1·5–1·75 mm. lati, *ovati* vel subrotundo-ovati, *acutiusculi* et inferne in stipitem quam pedicelli apex angustiorem contracti, paulum compressi et obscure carinati, siccitate apicis foveolis minutis distinctis plus minusve *rugulosi*.

! Corolla quam in typo major; foliorum laciniæ angustiores.

β. *Heldreichii*, Boiss. Fl. Orient. i. 137 (1867); Halácsy, *l. c.* 46 (1901). *F. Heldreichii*, Boiss. Diag. Pl. Or. Ser. II. No. 1, p. 16 (1853); Hamm. *l. c.* 33 (1857).

Exsicc. Haussknecht, Iter Græcum, 1885, Athenæ, in valle Cephissi, in Hb. Mus. Brit., ut *F. Heldreichii* !

Varietas habitu subscandente et *foliis* pallide virentibus in *lacinias lineari-oblongas* fissis. Bracteæ lineari-lanceolatæ, pedunculos fructiferos recurvos æquantes. *Corolla* plus 9 mm. longa, *pallide rosea. Fructûs* minimi, vix 2 mm. longi et paululum angustiores, *subrotundi* et breviter acutiusculi, levissime rugulosi. Aliter ut in typo.

The exsiccata of this variety, "Heldreich, Herb. Græc. Norm. No. 903," as represented in Herb. Mus. Brit., is a lax and vigorous plant with suberect fruiting pedicels and fruits less globose than ovoid. The station whence it was obtained, Mt. Pentelicos, produces a number of forms of this variable species.

γ. *deflexa*, var. nov.

F. deflexa, Heuffel in Flora, xxxvi. 619 (1853).

Exsicc. Heldr. Herb. Græc. Norm. No. 1005*b*, ut *F. Thuretii* f. *floribunda* !

Planta typo *robustior*, internodis longis sæpe scandens. *Folia* glauca, *laciniis lineari-oblongis* planis. *Racemi* sub-30-flori, floribus cernuis *laxiusculi*; bracteæ lineari-lanceolatæ pedicellos fructiferos arcuato-recurvos plus minusve incrassatos æquantes vel etiam superantes. *Corolla* 9–10 mm. longa, *rosea, quam in typo major.* Fructûs typi, nisi apicis foveolis paululum majoribus.

The fruits of this form are described by Heuffel as "subrotundis obtusis," but those observed in recent specimens from the Banatus (Degen, prope Orsovam, 1904!), as well as in Heldreich's Greek exsiccata, are of the subrotund-ovate, subacute form seen in the specific type.

!! Corolla quam in typo haud major; pedicelli fructiferi raro recurvi.

δ. *pikermiana*, var. nov.

F. pikermiana, Boiss. Diag. Pl. Or. Ser. II. No. 6, p. 9 (1859); Fl. Orient. i. 137 (1867); Haussk. *l. c.* 493 (1873); Halácsy, *l. c.* 48 (1901).

Icon. Stefani, Major & Barbey, Samos, tab. 5 (1891), ut *F. pikermiana*.

Exsicc. Guicciardi, No. 3189, Pikermi Atticæ, in Hb. Boiss.! Heldreich, No. 771, Chelidoni Atticæ, in Hb. Boiss., ut *F. bracteata*! Pichler, Pl. Græc. Exsicc., Eubœa, 1876, in Hb. Mus. Brit., ut *F. Thuretii* var. *glauca*! Haussk. Iter Græcum, Laurion, 1885, in Hb. Mus. Brit., ut *F. pikermiana*!

Caulis multo ramosa; *foliorum laciniæ lineari-oblongæ* sæpius obtusæ mucronatæ. *Racemi laxiusculi bracteis* sublanceolatis *pedicellos* incrassatos *patulos* vulgo *superantibus*. *Flores intense rosei*, eis typi similes sed *minores*; corolla 7–8·5 mm. longa. Fructûs minimi, vix 2 mm. longi, ovati, acutiusculi. Aliter ut in typo.

The material examined of this variety consists of branches of large plants gathered late and showing poor flowers. Although described as a distinct species by Boissier, and maintained as such both by Haussknecht and Halácsy, it is difficult to see how it essentially differs from *F. Thuretii*, of which it possesses the characteristic narrowly-winged corolla without (so far as can be seen) any spathulate dilation of the lower petal. The length of its bracts are sometimes equalled in other forms of this species, and it may be doubted whether its small flowers and spreading pedicels are not merely the result of a depauperate condition such as sometimes produces similar features in *F. capreolata*. The figure in 'Samos' also portrays the general features of *F. Thuretii*, excepting its recurved pedicels; and the absence of wings to the upper petal of the enlarged flower in this plate seems due to an artist's error, the wings being sufficiently indicated in the flowers of the racemes. In the absence of good material and in deference to the views of botanists acquainted with the living plant, *F. pikermiana* is retained as a variety.

The Zurich collection contains a number of varying depauperate or shade-forms of *F. Thuretii*, mostly much branched, and showing ample foliage and

relatively few-flowered racemes with small flowers and spreading fruiting pedicels. Some of these very closely approach this variety *pikermiana.*

ε. *thasia,* var. nov.

Exsicc. Sintenis & Bornmüller, Iter Turcicum, 1891, No. 447 (Limenas, Insula Thasos), ut *F. Thuretii*! Bornmüller, Iter Anatolicum tertium, 1899, No. 4046 (Mudania, Bithynia), ut *F. anatolica*!

Planta gracilis, scandens, racemis sub-20-floris, *pedicellis* fructiferis *gracilibus,* sæpius irregulariter *sub-patentibus* nec recurvis, *bracteâ* lanceolatâ acuminatâ plane *longioribus*; typi sepalis et corollâ, nisi *petali superioris alis* atropurpureis *apicem attingentibus carinamque superantibus*; fructibus minimis, vix 2 mm. longis et 1·5 mm. latis, subrotundo-ovatis, subacutis, in sicco minute rugulosis.

Hæc species variabilis ad *Fumariam Petteri* accedit, sed foliorum laciniis minoribus angustioribusque, pedicellis sæpissime arcuato-recurvis, floribus minoribus, sepalis magis ovatis, fructibus minimis nec inferne abrupte angustatis neque apice attenuatis specifice differre videtur.

F. Thuretii in Græciâ, ubi copiose crescere videtur, in Cypro, et in insulis Principum prope Byzantium invenitur; varietates *Heldreichii* et *pikermiana* in Græciâ; var. *deflexa* in Græciâ, in Banatu, et forsan in Hercegovinâ et in Montenegro; var. *thasia* in insulâ olim turcicâ Thasos, et in Bithyniâ.

This species, both as *F. Thuretii* and *F. pikermiana,* is placed by Haussknecht in the subsection *Latisepalæ* of the *Parvifloræ,* although included by Hammar among the *Capreolatæ.* Owing to its relatively fine leaf-cutting and large sepals it certainly approaches the Latisepalæ, but the examination of good and abundant material shows its floral features to be essentially those of the section *Grandiflora.*

27. FUMARIA REUTERI, Boissier, Diag. Pl. Or. ii. No. 8, p. 13 (1849), et Pugillus, 4 (1852), ex parte; Hamm. Mon. 35 (1857), excl. loc. not. Castell., pro parte. *F. Thuretii,* Boiss. (ex parte) ap. Haussk. in Flora, lvi. 494 (1873); *F. parviflora β. segetalis,* Hamm. *l. c.* 17, et Willkomm & Lange, Fl. Hisp. iii. 885 (1880), pro parte; *F. segetalis,* Coutinho, Fl. Portugal, 246 (1913).

Exsicc. Boissier, Sierra Nevada prope San Geronimo, in Hb. Boiss.! Ball, Iter Hisp. 35, ex regione subalpinâ montium S. Nevada, in jugis Cerro Tesoro et La Cartajuela, 5–6000 ft., in Hb. Kew, ut *F. bætica*! Reverchon, Pl. d'Andalousie, 1889, Sierra de Ronda, ut *F. media* var. *apiculata*! Reverchon, Pl. d'Espagne, 1891, No. 572, Sierra de Segorbe, Valence, ut *F. Bastardii*!

Fumaria annua, *gracilescens,* multo ramosa, suberecta vel diffusa, haud scandens. Folia irregulariter 3-pinnatisecta, foliolis in lacinias parvas confertas oblongas vel lineari-oblongas acutas vel mucronatas interdum subcanaliculatas fissis. *Racemi laxiusculi,* 10–18-flori, tandem elongati, *brevissime pedunculati* vel subsessiles. *Bracteæ* lineari-oblongæ, cuspidatæ, viridescentes, *pedicellis*

fructiferis apice parum incrassatis flexuosis irregulariter *patentibus* nec recurvis *paulo breviores*. *Sepala* 2·5–3 *mm. longa*, 1·5–2 *mm. lata*, *late oblonga*, peltata, breviter acuta vel obtusa mucronata, basi sæpius subtruncata, *integriuscula* vel parce irregulariter denticulata, præter nervum dorsalem viridiusculum albida, corollæ tubo æquilata. *Corolla* 9–10 *mm. longa*, *pallide rosea*; *petalo superiore* subacuto, *calcare magno* longicollo deflexo sepala superante et *alis atropurpureis* reflexis apicem attingentibus carinamque paululum superantibus prædito; *petalo inferiore marginibus* angustissimis *suberectis* nonnunquam ut in sectione *Parviflorarum* apice paululum dilatatis subacuto; petalis interioribus fere rectis apice atropurpureis. *Fructûs minimi*, angusti, circa 2 mm. longi, 1·5 mm. lati, *ovato-elliptici*, juxta medium latissimi, in *apicem acutiusculum* vel fere acutum et in stipitem angustissimum subæqualiter angustati, paulo compressi et plane carinati, siccitate apicis foveolis minutis distinctis *leviter rugulosi*.

Hæc rara planta, ab auctoribus multo confusa et a cl. Haussknecht ad *F. Thuretii* relata, ei sine dubio valde affinis est sed habitu minus robusto, foliorum laciniis confertis minoribus, racemis cum pedicellis patentibus haud multifloris, sepalis latioribus integriusculis, corollis pallidioribus petalo superiore latius alato calcareque longiore prædito, fructibus semper angustis stipitatis satis differt.

F. Reuteri in regione subalpinâ montium in Sierrâ de Ronda, in Sierrâ Nevadâ, et in Sierrâ Segorbe Hispaniæ australis, atque in Sierrâ de Serpa Lusitaniæ habitat, ubi indigena certe videtur.

The confusion that has occurred between *F. Reuteri* and *F. apiculata*, Lge., giving rise to a complicated synonymy, has been dealt with under the latter species.

A specimen collected at Granada by Lange was associated with *F. parviflora* by Hammar as a variety *segetalis* (Mon. *l. c.*), although at first referred to *F. Reuteri*. Lange himself also named this plant *F. Reuteri* (in Kjoeb. Vidensk. Meddel. 65 (1865)), but afterwards in the 'Flora Hispanica' he followed Hammar, remarking, however, "forsan specifice distinguenda." Hammar's diagnosis of his var. *segetalis* is too brief for certain determination, but Lange's clearly points to a plant specifically distinct from *F. parviflora*; and on its discovery and recognition in Portugal it was raised to specific rank as *F. segetalis* in Coutinho's recent 'Flora de Portugal.' Professor Coutinho has been kind enough to send an authentic Portuguese specimen which confirms its identity with the original Andalusian *F. Reuteri* of Boissier, and *F. parviflora β. segetalis*, Hamm. and *F. segetalis*, Coutinho, must accordingly be added to the synonymy of that species, with the modification "pro parte" in the case of the former, Hammar having also described the plant in question under the valid name *F. Reuteri*.

F. Reuteri approximates, both in flowers and in foliage, to the species of the section *Parviflora*, and more than any other member of this subsection shows

a slight apical dilation of the lower petal. It is retained among the *Grandifloræ*, however, as it is obviously much more closely allied to the preceding species *F. Thuretii* than to any member of the small-flowered group.

Sectio II. PARVIFLORA.

Parvifloræ, Pugsley, Fum. in Brit. 45 (1912). *Officinales*, Hamm. Mon. 9 (1857); *Angustisectæ*, Haussk. in Flora, lvi. 404 (1873).

Foliorum laciniæ planæ aut canaliculatæ, lanceolatæ vel anguste oblongæ usque ad lineares vel setaceæ (*F. montanâ*, Schmidt, exceptâ), nonnunquam mucronatæ. Flores rarissime quam in *F. officinali*, L. majores, plerumque minores, nec plus 9 mm. longi; petalum superius apice gibbum format cujus margines (alæ) vulgo sursum reflexi sed plus minusve erecto-patentes, rarius patuli sunt; petalum inferius apice gibbum monstrans qui margines patentes apicem versus plane dilatatos habet plus minusve spathulatum est. Petala interiora sæpius parum curvata, quam in sectione I relative latiora.

Subsectio IV. **LATISEPALÆ.**

Latisepalæ, Haussk. in Flora, lvi. 493 (1873); Pugsley, Fum. in Brit. 54 (1912). *Officinales*, Hamm. Mon. 9 (1857), ut sectio, ex parte.

Pedunculi breves (*F. montanâ* exceptâ) pedicellis plerumque apice valde incrassatis præditi. Bracteæ, nisi in *F. rostellatâ*, pedicellos fructiferos vulgo superantes. Sepala magna, sæpe parum dentata, longitudine corollæ tertiam partem saltem æquantia, ejusque tubo latiora. Petalum inferius quam in subsectionibus sequentibus obscurius spathulatum. Fructûs minimi usque ad majusculi, plus minusve subrotundi, siccitate rugosi, rugulosi vel sublæves.

In this subsection the wings of the upper petal are dark purple like the tip of the inner ones in *F. Kralikii*, *F. micrantha*, *F. bracteosa*, and *F. rostellata*, but sometimes obscurely so in *F. micrantha*. In *F. montana* the dark colouring appears to be absent not only from the wings of the upper petal but from the tip of the inner ones.

28. Fumaria montana, J. A. Schmidt, Beitr. Flora Cap Verd. Inseln, 263 (1852). (Pl. **11**, fig. 2.)

Exsicc. Schmidt—In rupestribus montium Ins. S. Antonii, März 1851, in Hb. Vindob.!

Fumaria annua, ut videtur, habitu modice robusto, satis ramosa, diffusa, petiolis cirrhosis scandens. *Folia* foliolis in *lobos oblongos vel cuneatos*, mucronatos, planos, obtusos vel rarius emarginatos fissis, infimis longiuscule petiolatis, irregulariter 2–3-pinnatisecta. *Racemi pauciflori* (10–12-flori), *laxiusculi*, *pedunculos* rectos crassiusculos *subæquantes*. *Bracteæ* lineari-lanceolatæ, acuminatæ, longissimæ, *pedicellis* fructiferis apice incrassatis

flexuosis et sæpius ut in *F. capreolatâ* arcuato-recurvis semper *longiores. Sepala* 3–3·5 *mm. longa*, 1·5–2 *mm. lata*, *lanceolato-ovata*, acuminata, peltata, *grosse serrato-dentata*, præter nervum viridiusculum albida, corollæ tubo paululum latiora. *Corolla* 6–7 *mm. longa*, *roseo-albida*; *petalo superiore subacuto alis albidis* patenti-reflexis apicem vix attingentibus et carinam viridem haud æquantibus prædito; *petalo inferiore marginibus patentibus* albidis subspathulato; petalis interioribus, ut videtur, omnino albidis. *Fructûs majusculi*, 2·5 mm. longi et 2·75 mm. lati, *subglobosi*, circa medium latissimi, in *apicem rotundato-obtusum* et in stipitem obscurum æqualiter angustati, paululum compressi sed insigniter carinati, in sicco dense sed tenuiter *rugosi*, nitidi, et apicis foveolis parvis angustis distinctis notati.

The diagnosis of this very rare fumitory, known only from the Cape Verde Island of S. Antonio and unique in its combination of small flowers and broad leaf-segments, is taken from Schmidt's specimen at Vienna, which has been lent for examination through the kindness of Dr. Zahlbruckner. This specimen now shows very few developed flowers, but such as remain are quite small, with the subspathulate lower petal clearly visible. The essential smallness of the flower is emphasized in Schmidt's very fair description, although, influenced probably by the broad leaf-segments, he contrasts it with *F. agraria* rather than any member of the *Parvifloræ*. Without more ample material it is perhaps impossible to determine with certainty the plant's exact affinities, but as not only the floral characters, both of sepals and corolla, but also the form of its fruit recalls the *Latisepalæ*, it seems preferable to place it in this group, in spite of its foliage, rather than to regard it as an Agrarian species with a degenerate corolla. In the dried specimen the peculiar unevenness of the leaf-margins alluded to by Schmidt does not now seem traceable.

F. montana is said to inhabit the rocks of the higher mountains of S. Antonio, probably at about 5000 ft. alt. (the highest point in the island is 7400 ft.), and even at this height, in the latitude of Cape Verde, the humid atmosphere may account in some measure for the development of its foliage.

The occurrence of an endemic species of the *Parvifloræ* on the west side of Africa is somewhat unexpected, but it may be noted that another species of this subsection, *F. bracteosa*, Pomel, is chiefly North African.

The relationship of *F. montana* with the endemic species of the Canaries that has been referred to it, is dealt with under *F. coccinea*.

29. Fumaria Kralikii, Jordan in Cat. Dijon, 19 (1848), et Linnæa, xxiii. 471 (1850); Hamm. Mon. 23 (1857). *F. anatolica*, Boiss. in Pinard, Pl. de Carie Exsicc. (1842), nomen solum, et Diag. Pl. Or. ii. No. 8, p. 14 (1849); Haussk. in Flora, lvi. 505 (1873).

Icon. Hamm. *l. c.* tab. ii.

Exsicc. Sintenis & Bornmüller, Iter Turcicum, 1891, No. 97, Dedeagatsch, ut *F. anatolica*! Schultz, Herb. Norm. Nov. Ser. Cent. 20, No. 1912, Nisch,

ut *F. anatolica*! Heldreich, Pl. Exsicc. Græciæ, No. 3479, ut *F. anatolica* (var. *minor*?)! Sintenis, Iter Thessalonicum, 1896, No. 433, ut *F. anatolica*!

This very pretty fumitory has the aspect, when dried, of a miniature *F. purpurea* owing to its recurved, purplish flowers with large, whitish sepals. It also recalls *F. Thuretii* in the abruptly terminated keels of the outer petals and the slight development of the wings of the upper one, but it may be readily distinguished by the subspathulate lower petal of its much smaller flowers, which do not exceed 7 mm. in length, as well as by its much more obtuse fruits.

F. Kralikii is well described by Jordan (*loc. cit.*), who is largely followed by Hammar, but its bracts are oblong or linear-oblong rather than oblong-obovate, the wings of the upper petal are narrow and do not cover the keel, and the very small, subglobose fruits (1·5–1·75 mm. long and broad), which show distinct if very small apical pits, are less "læves" than "sublæves vel leviter rugulosi." In some forms the racemes are at first very short and dense, though afterwards elongating.

In addition to the habitats cited by Haussknecht, this species grows in Bulgaria (Herb. Mus. Brit.) and in Armenia (Herb. Kew), and would thus seem to occur throughout the Balkan Peninsula and Asiatic Turkey, with the exception of Mesopotamia and Arabia. It is also represented in Herb. Mus. Brit. from the Crimea (Herb. Pallas, ut *F. officinalis*, partim), the label noting that it grows copiously on rocks.

30. Fumaria micrantha, Lagasca, Elench. Hort. Matrit. et Gen. Spec. Pl. Nov. 21 (1816); Hamm. Mon. 21 (1857); Pugsley, Fum. in Brit. 54 (1912). *F. densiflora*, DC. Cat. Hort. Monsp. 113 (1813), et Prodr. Syst. Nat. i. 130 (1824), ex parte; Haussk. in Flora, lvi. 507 (1873); *F. calycina*, Bab. in Trans. Bot. Soc. Edinb. i. 34 (1844); *F. mucronulata*, Schur, Enum. Pl. Transsilv. 38 (1866)?

F. tenuifolia, Gerard, Herb. 928 (1597), described from plants found in cornfields between Charlton and Greenwich. In Johnson's 'Gerard' the description was changed to fit *Platycapnos spicatus*, Bernh., with which it was generally confused by succeeding authors although apparently distinguished by Morison (Hist. ii. p. 262 (1680)) as *F. vulgaris minor tenuifolia*.

Icones. Eng. Bot. Suppl. 2876; Hooker, Icones, iv. tab. 363; Hamm. *l.c.* tab. ii.

β. *dubia*, var. nov. *F. micrantha* forma *dubia*, Pugsley, *l.c.* 57 & 58 (1912); *F. micrantha* γ. *Parlatoriana*, Rouy & Foucaud, Fl. Fr. i. 179 (1893)? non Boissier.

Icon. Fl. Danica, tab. 2472, ut *F. micrantha*.

Exsicc. Ridley & Fawcett, Wareham, in Hb. Mus. Brit.! Billot, Fl. G. & G. No. 709, ut *F. densiflora*!

In addition to the distinguishing features pointed out in "*Fumaria* in Britain," this variety is usually somewhat less robust and more freely branched than the specific type. Rouy & Foucaud's description of var. *Parlatoriana* seems to refer to this plant rather than that so named by Boissier.

[γ. *littoralis*, Rouy & Foucaud, Fl. Fr. i. 179 (1893); n. v. *F. littoralis*, Du Mortier, Bull. Soc. Roy. Bot. Belg. vii. 359 (1868). This plant is allied to the preceding variety, being much branched and having similar relatively narrow sepals; but it appears to be separable owing to its broader leaf-segments and short racemes of pale flowers.]

It is noteworthy that prior to the appearance of Grenier & Godron's 'Flore de France' in 1847, *F. densiflora* DC. was not associated by botanists with this species. This may be seen not only from De Candolle's works, but in Sibthorp & Smith's 'Flora Græca,' vii. p. 63, in Moris's 'Flora Sardoa,' i. p. 90, and in Arnott's paper on the genus in Rep. Bot. Soc. Edinburgh, p. 104 (1840).

F. micrantha is shown in "*Fumaria* in Britain" to be eminently a Mediterranean species. The varieties *dubia* and *littoralis* are at present known only from Western Europe.

31. Fumaria bracteosa, Pomel, Nouv. Mat. Fl. Atlant. 239 (1874). *F. densiflora β. bracteosa*, Batt. et Trabut, Fl. de l'Algérie, i. 29 (1888); *F. Parlatoriana*, Kralik, Pl. Ægypt. Exs. (nomen); *F. micrantha β. Parlatoriana*, Boiss. Fl. Orient. i. 137 (1867); *F. densiflora β. Parlatoriana*, Haussk. in Flora, lvi. 510 (1873).

Exsicc. Letourneux, Pl. Ægypt. No. 229*a*, Mariout, 1879, ut *F. densiflora* (partim)! Bornmüller, Iter Syriacum, 1897, No. 43, Jaffa, ut *F. Parlatoriana*! Sintenis & Rigo, Iter Cyprium, 1880, No. 175, ut *F. parviflora*!

Fumaria annua, caulibus crassis elongatis *robusta*, parce ramosa, diffusa, suberecta, vix scandens. *Folia* glauca foliolis in *lacinias* angustissimas *lineari-setaceas* canaliculatas acutas fissis 2–4-pinnatisecta. *Racemi* floriferi *densissimi*, fructiferi laxiores, *multiflori* (20–30-flori), *pedunculos* crassos brevissimos *multo superantes*. *Bracteæ magnæ*, *lineari-oblongæ*, acuminatæ, viridescentes, *pedicellis* fructiferis *erecto-patentibus brevissimis* (circa 2 mm. longis) apicem versus conspicue incrassatis plane (sæpe subduplo) *longiores*. *Sepala* 1·5–2 *mm. longa*, ·75–1·25 *mm. lata*, *rotundato-ovata vel ovato-lanceolata*, peltata, acuminata, *denticulata*, nervo dorsali roseo albida. *Corolla minima*, 3·5–4·5 *mm. longa*, *pallide rosea*; *petalo superiore subacuto alis atropurpureis* carinam conspicuam viridem haud æquantibus apicemque vix attingentibus atque *calcare brevissimo* fere gibbiformi; *petalo inferiore* marginibus angustis roseis *subspathulato*; petalis interioribus apice atropurpureis. *Fructûs modici*, circa 2 mm. longi et lati, *subrotundi*, *obtusissimi vel subtruncati*, parum compressi sed conspicue carinati, siccitate apicis foveolis obscuris plane *rugosi*.

Hæc *Fumaria* quæ *F. micranthæ* faciem eximie exhibet et pro varietate ejus speciei a pluribus auctoribus habetur, per flores generis minimos breviter calcaratos notabilis est, et hoc charactere cum foliorum laciniis setaceis, pedicellis brevissimis, fructibusque conspicue carinatis specifice differre videtur.

F. bracteosa Palæstinam (Jaffa (Bornmüller)! et prope Beersheba (Hb. Mus. Brit.)!), Mesopotamiam (Schläfli, prope Bagdad, in Hb. Kew!), insulam Cyprum, Ægyptum (prope Alexandriam!) et Algeriam (Faure, prope Oran!) habitat.

This, the smallest flowered of all fumitories, is shown as a distinct species rather than a variety of *F. micrantha*, chiefly on account of its corolla, which is not only remarkably small but of characteristic form with a much diminished spur. This feature is quite constant in the different herbarium material examined, some of which shows good and abundant flowers, and there seems no sufficient reason for regarding the plant as a depauperate form or condition of *F. micrantha*.

32. Fumaria rostellata, Knaf in Flora, xxix. 290 (1846); Hamm. Mon. 20 (1857); Haussk. in Flora, lvi. 510 (1873). *F. transsilvanica*, Schur (=*F. macrosepala*, Schur, non Boiss.), Enum. Pl. Transsilv. 38 (1866), ap. Haussk. *l. c.*

Icon. Hamm. *l. c.* tab. ii.

Exsicc. Celakovsky, &c. Fl. Exsicc. Austro-Hungarica, No. 2902!

An authentic example of *F. prehensilis*, Kit. in Hb. Mus. Brit. is identical with this species, but according to Parlatore specimens of *F. micrantha* were sent out by Kitaibel under this name, and the posthumous diagnosis of *F. prehensilis* in Linnæa, xxxii. p. 493 (1863), shows evident confusion between *F. rostellata* and *F. officinalis*. It thus seems clear that Hammar and Haussknecht were wise in passing over Kitaibel's name (Ind. Pl. Hort. Pesth, p. 10 (1812)), though anterior to both *F. micrantha* and *F. rostellata*.

Another name that appears to have been generally overlooked is *F. Sturmii*, Opiz in Naturalientausch, x. p. 267 (1825). This is referred to *F. micrantha* in the 'Index Kewensis,' but both the diagnosis and the habitats cited recall *F. rostellata*, and if this identification can be confirmed from authentic exsiccata, the name *F. Sturmii* must be used in preference to *F. rostellata*.

Knaf's description of this species is accurate and fairly complete, and is largely followed by Hammar. The fruiting pedicels are slenderer and the bracts smaller than in the other plants of this subsection, and the pedicels are by no means always short as stated in Hammar's diagnosis. In some agrestal forms with highly coloured flowers in very floriferous racemes the wings of the upper petal are much developed and extend almost to the apex, which is then no longer rostellate though still acute. Such plants are possibly varietally distinct.

There is also some degree of variation in the fruit, which is sometimes plainly longer than broad and occasionally very shortly acute. Its surface, when dry, is usually finely rugulose.

The range of *F. rostellata*, a plant of Central Europe, extends as far north as Lithuania (Grodno, in Hb. Kew!), and in addition to the habitats cited by Haussknecht, it occurs in Serbia (Hb. Kew) and in Bulgaria (Hb. Mus. Brit.).

Subsectio V. **OFFICINALES.**

Officinales, Haussk. in Flora, lvi. 404 (1873); Pugsley, Fum. in Brit. 45 (1912); Hamm. Mon. 9 (1857), ut sectio, ex parte.

Pedunculi breves vel breviusculi, nisi in *F. Boissieri*, pedicellis sæpius apice parum incrassatis prædìti. Bracteæ pedicellis fructiferis breviores (*F. microstachys* exceptâ). Sepala haud magna, plus minusve dentata, raro corollæ tertiâ parte longiora, ejusque tubo (nisi in *F. microstachys*) angustiora. Fructûs modici aut maximi, conspicue lati, truncati vel retusi, siccitate rugosi rarius rugulosi.

In *F. officinalis* and *F. microstachys* the wings of the upper petal are normally dark purple like the tip of the inner ones, but this colouring is obscure in *F. cilicica* and *F. Boissieri*.

33. Fumaria officinalis, Linn. Spec. Plant. 700 (1753); Hamm. Mon. 9 (1857); Haussk. in Flora, lvi. 404 (1873); Pugsley, Fum. in Brit. 45 (1912). *F. vulgaris*, Bubani, Fl. Pyr. iii. 278 (1901).

F. purpurea et *F. flore albo*, Gerard, Herb. 927 (1597); *F. vulgaris*, Parkinson, Theatr. Bot. 287 (1640).

Icones. Woodville, Med. Bot. ii. tab. 88 (floribus pallidis ad var. *elegantem* accedens); Smith, Eng. Bot. 589; Curtis, Fl. Lond. i. tab. 147 (fasc. ii. 52) (forma *agrestis*, Haussk.); Wagner, Pharm.-Med.-Bot. tab. 59; Fl. Danica, tab. 940 (f. *floribunda*, Pet. ex Haussk.); Hayne, Gewächse, v. tab. 4; Sturm, Deutschl. Fl. i. 62, tab. 14, ut *F. officinalis* var. *major*; Svensk Bot. i. tab. 42; Reichb. Icones Fl. Germ. iii. tab. 3, fig. 4454, cum var. *scandente*; Hamm. *l. c.* tab. i; Clavaud, Fl. Gironde, pl. 4, fig. 1.

As pointed out in the general remarks on the subsection *Murales*, *F. media*, Loiseleur, 'Notice' p. 101 (1810), is closely related to this species. Loiseleur separates it from *F. officinalis* by its more rampant habit, ample foliage, and larger, paler flowers; and it seems best regarded as a large-flowered state of the plant figured by Reichenbach, without diagnosis, as *F. officinalis* var. *scandens*, which was reduced to a *forma scandens* in "*Fumaria* in Britain," p. 51. It is perhaps also the *α. vulgaris* of Koch, Syn. Fl. Germ. ed. 2, App. p. 1017 (1845), and of Hammar (Mon. p. 10), but it is not clear whether these authors intend to distinguish under this name a variety separable from the specific type.

! Racemi quam in typo breviores, relative pauciflori ; sepala minora.

β. minor, Koch in Sturm Deutschl. Fl. i. 62, No. 14 (1833) ; Syn. Fl. Germ. ed. 2, App. 1018 (1845) ; Hamm. *l. c.* 10 (1857) ; Haussk. *l. c.* 419 (1873) ; Pugsley, *l. c.* 52 (1912).

Icon. Sturm, Deutschl. Fl. i. 62, tab. 14.

Exsicc. Orphanides, Fl. Græca, No. 519, ut *F. officinalis* var. *laxiflora* !

Glauca, tenella, diffusa et sæpe ramosissima. *Racemi laxiusculi*, 10–20-*flori*. *Sepala parva, circa* 2 *mm. longa*; *corolla quam typi* paulo *minor* pallidiorque. Fructûs ut in typo latiores quam longi, 2 mm. longi et 2·5 mm. lati, retusi.

The comparatively short and few-flowered racemes and the small sepals characteristic of this variety were first accurately diagnosed by Hausknecht, but the former feature and the relatively small, pale flowers seem sufficiently shown in Koch's original figure.

In Herb. Mus. Brit. there are Crimean specimens from Herb. Pallas seemingly referable to this variety labelled "In rupibus Tauriæ ubique." It may be inferred from this that the plant grows in natural stations in that country, and this appears to be confirmed in M. Bieberstein's 'Fl. Taurico-Caucasica,' ii. 147 (1808), where it is observed, under *F. officinalis*, "Habitat in ruderatis et arvis, varietas minor in saxosis."

It is probable that *F. Meyeri*, Steven, Enum. Pl. Phaner. in Tauriâ sponte crescentium in Bull. Soc. Bot. Mosc. xxix. i. 288 (1856), is identical with this variety.

γ. Wirtgenii, Haussk. *l. c.* 411 & 420 (1873) ; Pugsley, *l. c.* 52 (1912). *F. Wirtgenii*, Koch, Syn. Fl. Germ. ed. 2, App. 1018 (1845).

Icon. Pugsley, *l. c.* fig. 6 (Journ. Bot. l. tab. 519).

Exsicc. Dörfler, Herb. Norm. No. 4601, ut *F. Wirtgenii* !

Habitu foliisque variabilis, sed sæpe typo gracilior foliorum laciniis paulo angustioribus. *Racemi laxiusculi, vulgo* 10–20-*flori* ; pedicelli quam in typo breviores et crassiores, rarius plus minusve elongati. *Sepala parva, circa* 2 *mm. longa et* 1 *mm. lata*, sæpius albida et vix acuminata. *Corolla quam typi* paulo *minor* pallidiorque, *petalorum exteriorum alis apice valde dilatatis* ut petala superius emarginatum et inferius truncato-spathulatum fiant. *Fructûs* 2–2·5 *mm. longi et vix latiores*, rotundato-truncati sed *haud retusi*, sæpissime apiculo parvo persistente prædití, circa medium latissimi et inferne in stipitem quam in typo minus obscurum angustati, siccitate apicis foveolis obscuris plane rugosi.

The exsiccata, Billot No. 1603 (*F. Wirtgenii*, Koch), as represented in Herb. Boissier, clearly belongs to this variety and is not identical with the example similarly labelled in Herb. Mus. Brit. which is referred to var. *elegans* in "*Fumaria* in Britain."

!! Racemi longi, multiflori; foliorum laciniæ quam in typo angustiores.

δ. *densiflora*, Parlatore, Mon. Fum. 53 (1844); Haussk. *l. c.* 421 (1873). *F. densiflora*, DC. Cat. Hort. Monsp. 113 (1813), et Prodr. Syst. Nat. i. 130 (1824), ex parte; *F. officinalis* var. *floribunda*, Koch, Syn. Fl. Germ. ed. 2, App. 1018 (1845), ex parte; Hamm. *l. c.* 10 (1857); *F. officinalis* var. *pycnantha*, Loret & Barr. Fl. Montp. ed. 1, 32 (1876); *F. parviflora*, Sibth. & Smith, Fl. Græc. Prodr. ii. 50 (1813), et Fl. Græc. vii. 63 (1830)? non Lamarck.

Icon. Sibth. & Smith, Fl. Græc. vii. tab. 668, ut *F. parviflora*.

Exsicc. Bourgeau, Pyr.-Espag. No. 394, ut *F. officinalis*! Welwitsch, Fl. Lusit. Nos. 136 & 764, ut *F. officinalis* var. *parviflora*!

The *F. parviflora* of Sibthorp & Smith was referred by Hammar to *F. micrantha*, to which the description, at least as to its subglobose fruits, may be held to apply. The figure, however, has evidently been drawn from an example of this variety of *F. officinalis*, which it very well portrays, except for the obscurely shown fruits. Both the corolla and the sepals are widely different from those of any form of *F. micrantha*.

It is also probable, though not equally certain, that this variety is the *F. officinalis* var. *densiflora* of Moris's 'Flora Sardoa,' i. p. 90 (1837).

ε. *elegans*, Pugsley, *l. c.* 52 (1912). *F. media*, Reichb. Icon. Fl. Germ. iii. 1 (1838), nec Lois. nec aliorum.

Icon. Reichb. *l. c.* tab. 2, fig. 4453, ut *F. media*.

Exsicc. Billot, Fl. G. & G. No. 214, ut *F. officinalis*! Fiori & Béguinot, Fl. Exsicc. Ital. ii. No. 1050, ut *F. officinalis*!

This plant is well marked by its ample glaucous foliage with narrowly lanceolate segments, by its long racemes of usually pale flowers, and by its small fruits borne on long and slender pedicels subtended by relatively short bracts. These features do not agree with those of Loiseleur's *F. media*, but are emphasized by Reichenbach, either in his plate or his diagnosis, where the plant is referred to as a "species constantissima."

Continental examples occasionally show finer flowers than those from which the description in "*Fumaria* in Britain" was taken, and present somewhat the appearance of a rampant state of var. *densiflora*.

Hammar cites Reichenbach's figure of *F. media* for his var. *scandens*, but his description depicts a different plant with broad leaf-segments and large fruits, whose affinity may be held uncertain.

The variety *albiflora*, Parlatore, Mon. p. 53, with which the author identifies *F. Gasparinii*, Bab. in Trans. Bot. Soc. Edin. i. 36 (1844), is referred by Hammar to var. *minor*. No material of this species has been seen, however, with the white flowers by which var. *albiflora* is distinguished, and it seems probable that this character was taken from a shade-form only.

Of the var. *banatia*, Haussk. *l. c.* 421 (1873), no authentic material has been examined, and its identity with Reichenbach's var. *scandens* seems to require further investigation.

The varying states of this fumitory, as it is seen in cornfields in spring, in gardens in summer, and when shade-grown, are carefully distinguished by Haussknecht under the three form-names, *floribunda*, Peterman, *agrestis*, and *umbrosa*; and the parallel variations of the variety *Wirtgenii* are similarly dealt with, as also those of the species *F. Schleicheri*, Soy-Will., *F. Vaillantii*, Lois., and *F. parviflora*, Lam. These variations, which Haussknecht remarked in the species familiar to him, probably occur generally throughout the genus where the climatic conditions are favourable for the continued propagation and growth of the plants throughout the summer.

The distribution of *F. officinalis*, as given by Hammar, is amended by Haussknecht and in "*Fumaria* in Britain." It is pre-eminently the common European Fumitory, but both in Asia and North Africa it is scarcer and less widely spread than *F. parviflora*.

Haussknecht further enumerates a number of widely scattered localities for the varieties *minor*, *Wirtgenii*, and *densiflora*; and it may be added that var. *elegans* occurs not only in Britain, France, and Germany, but also in Italy and Spain.

A hybrid of the variety *Wirtgenii* with *F. Vaillantii* var. *Chavinii* has been described from the Var in Southern France as × *F. Albertii* in Rouy & Foucaud's Fl. de France, i. p. 178 (1893); and in the same year another description of *F. officinalis* × *Vaillantii* (*F. abortiva*) from Thessaly was published by Haussknecht in Mittheil. Thür. Bot. Ver. N. Folge, iii. & iv. p. 102 (Symbolæ ad floram græcam). There is an authentic example of this latter plant in Herb. Kew. *F. officinalis* × *parviflora* and *F. officinalis* × *micrantha* are referred to at page 50 of "*Fumaria* in Britain."

34. Fumaria cilicica, Haussk. in Flora, lvi. 423 (1873). *F. officinalis* γ. *tropidocarpa*, Buser in Fl. Orient. Suppl. 26 (1888).

Exsicc. Kotschy, Iter Cilicico-Kurdicum, 1859, No. 42, ut *F. officinalis* var. *floribunda*! Bourgeau, No. 32, Trebizond, 1862, in Hb. Boissier, ut *F. officinalis*! Balansa, Vallée de Djimil, Lazistan, 1866, in Hb. Boissier, ut *F. officinalis*! Zorab, No. 417, Erzerum, ut *F. officinalis*! Darbes, Syria Libanotica, 1881, in Hb. Zürich, ut *F. officinalis*! Pl. Auraniticæ, Postian ap. Coll. Syriens. Prot., El Kafr, 1886, ut *F. officinalis* var. *tropidocarpa*! Sintenis, Iter Orient., 1894, No. 5495, Armenia Turcica!

In addition to authentic material of Kotschy's plant on which this species was founded, the herbaria at Kew and the British Museum contain excellent Armenian examples collected by Sintenis, which are labelled as referred by Haussknecht to *F. cilicica*.

In these examples the characters of this remarkably floriferous and somewhat showy fumitory are well seen, and they generally confirm the accuracy of Hausskneckt's unusually full diagnosis.

After an examination of the exsiccata cited it may be remarked that, compared with *F. officinalis*, *F. cilicica* seems chiefly notable for its very long and dense racemes, bearing from 30 up to 80 flowers and much exceeding the short and thick peduncles. Its bracts, also, are more subulate and more finely pointed, while the sepals are relatively small and narrow and, at least in some cases, acuminate rather than mucronate. The corolla is rather larger than in *F. officinalis* (8–9 mm. long), with broad, short, obscurely purple wings to the upper petal much exceeding the keel and extending to its apex; the spur ascending, longer and more curved than in *F. officinalis*; and the lower petal less spathulate, and subacute with spreading margins scarcely reaching the apex. The apical pits of the fruit are roundish and shallow, and the persistent apiculus, while apparently invariably present, is sometimes very short, giving the fruit a strong resemblance to that of *F. officinalis*. On this ground Buser seems to have reduced this plant to a variety of that species.

It will be seen from the exsiccata cited that *F. cilicica* has a wide distribution in Asiatic Turkey.

35. Fumaria Boissieri, Haussk. in Flora, lvi. 424 (1873); Buser in Fl. Orient. Suppl. 27 (1888).

Exsicc. Haussk. Terek Mesopotamiæ borealis, 1867, in Hb. Boissier!

This species, described by Haussknecht from plants which he himself collected in Northern Mesopotamia, seems from the exsiccata in Herb. Boissier—the only material examined—to be separable with difficulty from *F. cilicica*.

In the Boissier specimen, which shows good foliage and flowers though only immature fruit, the leaves, racemes, pedicels, bracts, and sepals appear to be essentially those of *F. cilicica*; and although the outer petals are more broadly winged and the apiculus of the young fruit is longer than in the Kotschy gathering which forms the type of *F. cilicica*, yet it is clear from the more recent material referred to this species that these features are liable to an appreciable range of variation.

Although Buser retains *F. Boissieri* as a species while he reduces *F. cilicica* to a variety of *F. officinalis*, it is apparent that he recognizes the very close affinity of the three plants.

36. Fumaria microstachys, Kralik ex Haussk. in Flora, lvi. 552 (1873). *F. judaica β? microstachys*, Buser in Fl. Orient. Suppl. 29 (1888).

Exsicc. Kralik, Alexandrie, Egypt, 1847, in Hb. Boissier! et Hb. Kew! Gaillardot, Pl. d'Egypte, No. 437, Alexandrie, 1870, ut *F. Vaillantii*?! Schweinfurth, Basse-Egypte, No. 267, Alexandria, 1890, ut *F. judaica*!

Fumaria, ut videtur, annua, *satis robusta*, diffusa, tandem ramosissima. *Folia* plus minusve glauca, foliolis in *lacinias lineari-oblongas*, planas, acutas vel obtusas raro mucronatas fissis 3–4-pinnatisecta. *Racemi laxiusculi, pauciflori*

(6–12-flori), *primarii pedunculos subæquantes, seriores* pedunculos brevissimos *multo superantes. Bracteæ* subulato-lanceolatæ, breviter acuminatæ, *pedicellos* fructiferos *erecto-patentes* brevissimos (2 mm. longos) apice valde incrassatos *subæquantes vel superantes. Sepala circa* 1·5–2 *mm. longa,* ·75 *mm. lata,* sæpius *ovata,* acuminata, *dentata,* albida. *Corolla* 5–7 *mm. longa, pallide rosea* ; petalorum exteriorum carinis abrupte terminatis, alis atropurpureis marginibusque roseis in exemplaribus visis haud bene explicatis; petalis interioribus apice atropurpureis. *Fructûs maximi,* 3 mm. longi et paululum latiores, *brevissime obcordati, retusi,* supra medium latissimi et inferne in stipitem obscurum multo angustati, parum compressi sed conspicue carinati, in sicco apicis foveolis latis obscuris *rugosi.*

Hæc *Fumaria* distinctissima propter fructûs maximos cum *F. judaicâ* vulgo confusa est. In exemplaribus visis flores haud satis explicantur, sed corollas formam sectionis *Parviflorarum* exhibere manifestum est.

F. judaica foliorum laciniis majoribus latioribus, pedunculis pedicellisque longioribus, sepalis angustioribus, corollis albidis multo majoribus cum petalo inferiore haud spathulato, fructibus paulo minoribus, obscurius carinatis, magis tuberculato-rugosis longe distat.

F. microstachys in Ægypto solo (prope Alexandriam) hactenus inventa est.

This remarkable fumitory, of whose position in the genus Haussknecht expressed some doubt owing to lack of adequate material, and of which good flowering specimens are still wanting in British herbaria, is unique among the *Parvifloræ* on account of its very large fruits. In habit it evidently approaches *F. officinalis* and *F. Vaillantii,* which in some degree it probably resembles also in flower, but its fruits recall *F. macrocarpa* and *F. judaica* of the *Grandifloræ,* and it thus seems a somewhat anomalous intermediate between these widely different species. As a member of the *Parvifloræ* it seems best placed in the subsection *Officinales* on account of the moderate size of its sepals and the broad form of its fruits.

Subsectio VI. **MICROSEPALÆ.**

Microsepalæ, Pugsley, Fum. in Brit. 59 (1912). *Officinales,* Hamm. Mon. 9 (1857), ut sectio, ex parte; *Parvifloræ,* Haussk. in Flora, lvi. 441 (1873).

Pedunculi plus minusve breves, rarius obsolescentes (*F. australi* exceptâ), pedicellis incrassatis tenuibusve præditi. Bracteæ variabiles. Sepala minima (nisi in *F. Jankæ* et *F. australi*) vel etiam absentia, sæpissime insigniter dentata, vulgo corollæ quartâ parte breviora ejusque tubo sæpissime multo angustiora. Fructûs parvi vel modici, rarissime conspicue lati, siccitate rugosi vel rugulosi.

The blackish-red wings of the upper petal so generally characteristic of the genus are well marked in the deep rose corollas of *F. Schleicheri* and *F. Jankæ,* and in the lighter flowers of *F. microcarpa.* They become less marked in

F. abyssinica, and are generally obscure in *F. indica* and *F. Schrammii*, while in *F. Vaillantii* the dark colouring is fairly distinct in some forms and quite absent in others.

In *F. parviflora* the normally white corolla usually shows a small external blotch only of purple on the wings of the upper petal, recalling the coloration of *F. occidentalis*; and in *F. asepala* the purple tinting, if present at all, is confined to the tips of the inner petals.

* Series **Ambiguæ**.

Flores rosei, 5–7 mm. longi; sepala 1·5–2 mm. longa; petali superioris alæ sursum reflexæ vel obsolescentes deflexæ.

37. Fumaria abyssinica, Hamm. Mon. 19 (1857); Haussk. in Flora, lvi. 492 (1873).

Icon. Hamm. *l.c.* tab. vi.

Exsicc. Schimper, Iter Abyss., sec. secunda, 1842, No. 1347, Demerki, ut *F. officinalis*! Schimper, Abyss. 1863, No. 1429 (shade-form)! Ankober, 1841, in Hb. Kew! Fl. Colon. Eritræa, 1902, No. 207, in Hb. Mus. Brit.! Schweinfurth, 1889, No. 1675, El Ejan am Schibam (2700 m.), Arabia Felix, in Hb. Kew!

There is good material in Herb. Mus. Brit. of the plant on which this species was founded. As pointed out by Haussknecht (*l.c.*), the fruit is scarcely obtuse, as stated in Hammar's diagnosis, but rather mucronulate when young, and at maturity subacute and very shortly apiculate, much as in some forms of *F. parviflora*, though the keel is less marked than in that species. In the Eritræan exsiccata a somewhat more rounded-obtuse, though still apiculate form prevails. The fruit is 2–2·25 mm. long and about equally broad, with very shallow apical pits.

It may further be remarked that the leaf-segments in *F. abyssinica* are more generally linear-oblong than oblong-lanceolate; and the racemes, which are usually sub-12-flowered in Schimper's examples but show as many as 20 flowers in the Eritræan exsiccata, are much longer in fruit than the very short peduncles, except occasionally when shade-grown. The bracts seem to be relatively broad—linear-oblong rather than linear—and fully as long as the short (2 mm. long), suberect pedicels. The ovate, acuminate sepals are about 1·5 mm. long and 1 mm. broad; the purple wings of the obtuse upper petal are reflexed upwards as in *F. officinalis* or in *F. Schleicheri*, but are normally rather narrow and scarcely cover the keel; and the lower petal appears less distinctly spathulate than in most of the other species of the subsection.

In the Arabian specimen at Kew the wings of the outer petals are but little developed, and the obscurely apiculate fruit is more rounded-obtuse than in the Abyssinian type.

The range of *F. abyssinica* is now known to extend from Abyssinia to the Italian coast colony of Eritræa and across the Red Sea to Arabia Felix. There is also an immature specimen from Uganda in Herb. Mus. Brit. (Bagshawe, Ruchiga, No. 396 !) which seems referable here. It appears to occur only at a considerable altitude. *F. abyssinica* is further recorded on Haussknecht's authority for Gabes in Murbeck's 'Contributions Fl. du Nord-Ouest de l'Afrique,' p. 5 (1897).

The material collected in the Kilimandjaro district of East Africa as *F. abyssinica* is referred to a distinct species *F. australis.*

38. FUMARIA AUSTRALIS, sp. nov. (Pl. **13**.)

Exsicc. Volkens, Fl. des Kilimandscharo, 1893, Nos. 953 & 1333, Marangu (2800 m.) et Fuss des Kifinnka (2700 m.), ut *F. abyssinica* ! Whyte, Nandi District, Tropical E. Africa (2000 m.), 1898, in Hb. Kew !

Fumaria verisimiliter annua, *habitu* satis *robusto*, internodis longis elongata, petiolis cirrhosis scandens. *Folia glauca*, foliolis in *lacinias* planas *lineari-lanceolatas* vel lanceolatas, acutas, *longe mucronatas* vel aristatas fissis 2–3-pinnatisecta. *Racemi* 12–20-flori, floriferi *conspicue densi*, etiam fructiferi *pedunculis mediocribus* paulo *breviores*, rarius eos subæquantes. *Bracteæ magnæ* et conspicue latæ, oblongæ, cuspidatæ, sparsim serrulatæ, *pedicellis fructiferis brevissimis* (circa 1·5 mm. longis), crassis, *erecto-patentibus subduplo longiores*. *Sepala circa 2 mm. longa, 1 mm. lata, oblongo-ovata*, acuta, *irregulariter dentata*, rosea. *Corolla 5–7 mm. longa, rosea*; *petalo superiore alis roseis* angustissimis *fere obsoletis* sæpissime deflexis apicem haud attingentibus *acuto*, calcare brevi parum curvato; *petalo inferiore* marginibus patentibus apicem vix attingentibus subacuto *subspathulato*; petalis interioribus apice atropurpureis. *Fructûs modici*, circa 2·25 mm. longi ac lati, *subrotundi*, superne *cum apiculo brevissimo* persistente *obtusiusculi*, inferne in stipitem latum parum angustati, paululum compressi sed plane carinati, in sicco apicis foveolis obscurissimis *dense rugosi.*

Hæc *Fumaria*, quæ ad *F. abyssinicam* relata est, habitu laxiore scandente, foliorum laciniis fere aristatis nonnunquam latioribus, racemis densis longius pedunculatis, bracteis majoribus, et præsertim corollis acutis petalique superioris alis angustissimis deflexis nec sursum reflexis satis differt.

Ab hujus subsectionis speciebus aliis per corollæ formam subexalatam *F. australis* æqualiter distat. Petali superioris alæ fere obsoletæ eis *F. coccineæ* similes sed specierum duarum characteres reliqui omnino diversi sunt.

F. australis in regionibus Kilimandjaro et Nandi Africæ orientalis crescit.

The exsiccata collected by Volkens, though elongate, show highly coloured and what seem to be normally developed flowers, and appear to be the usual form of a southern endemic species.

39. FUMARIA JANKÆ, Haussk. in Flora, lvi. 491 (1873).

Exsicc. Janka, Szekelyhid com. Bihar Hungariæ, 1861, in Hb. Boiss.!

The only material examined of this rare Hungarian plant is the specimen from Janka in Boissier's Herbarium. This shows poor flowers, but has the appearance of a distinct species agreeing with Haussknecht's diagnosis except in the length of the pedicels, which seem distinctly shorter than those of *F. Schleicheri.*

F. Jankæ is evidently somewhat intermediate between *F. rostellata* and *F. Schleicheri*, and is retained in this subsection in accordance with the views of Haussknecht.

** Series **Eu-Microsepalæ.**

Flores rosei vel albidi, raro plus 6 mm. longi; sepala minuta (·5–1·5 mm. longa) vel absentia; petali superioris alæ sursum reflexæ, erecto-patentes vel patulæ.

40. FUMARIA SCHLEICHERI, Soyer-Willemet, Observ. Pl. France, 17 (1828); Haussk. in Flora, lvi. 411 & 485 (1873). *F. Vaillantii*, subsp. *Schleicheri*, Rouy & Foucaud, Fl. Fr. i. 181 (1893); *F. Laggeri*, Jordan, Pugillus, 7 (1852); *F. tenuiflora*, Fries Herb. ex Hamm. Mon. 13 (forma umbrosa), et *F. Vaillantii β. Laggeri*, Hamm. Mon. 15 (1857); *F. acrocarpa*, Peterman (nomen ?).

Icon. Hamm. *l. c.* tab. i, ut *F. Wirtgenii* (sic).

Exsicc. Schultz, Herb. Norm. No. 2109! Borbas, Fl. Exsicc. Austro-Hungarica, No. 2903 II!

Fumaria annua, *gracilescens*, satis ramosa, suberecta vel diffusa, rarius petiolis cirrhosis scandens. *Folia* plus minusve glauca, foliolis in *lacinias* planas *lineari-oblongas* vel lineari-lanceolatas, acutas rarius mucronatas fissis 2-(rarius 3-) pinnatisecta. *Racemi* floriferi *densiusculi*, sæpissime 12–20-, rarius plus 20-flori, fructiferi laxiores, *primarii pedunculos* graciles *subæquantes seriores* plane *superantes*. *Bracteæ* lanceolato-subulatæ, acuminatæ, *pedicellis* fructiferis *suberectis* gracilibus (4 mm. longis) apice ipso incrassatis fere *triplo breviores*. *Sepala circa* 1 *mm. longa*, ·5–·75 *mm. lata*, *ovata*, acuminata, irregulariter *inciso-dentata*, rosea, corollæ tubo plane angustiora. *Corolla* 5–6 *mm. longa*, *saturate rosea* (in sicco sub-violacea); *petalum superius obtusum alis atropurpureis sursum reflexis* carinam viridem excedentibus apicemque attingentibus et calcare longo curvato præditum; *petalum inferius* marginibus patulis roseis apicem vix attingentibus *obtusiusculum spathulatum*; petala interiora apice atropurpurea fere recta. *Fructûs modici*, circa 2 mm. longi ac lati, *subrotundi*, superne *cum apiculo* brevi persistente *rotundato-obtusi* (rarissime sine apiculo), inferne parum angustati, paulo compressi et plane carinati, siccitate apicis foveolis parvis paulo obscuris *rugosi.*

β. supina, var. nov.

F. supina, Janka in Termesz Füzetek, i. 30 (1877).

Exsicc. Janka, Noszoly et Feketelak, Transsilvaniæ centralis, 1876, in

Hb. Kew! Szépligeti, Fl. Hungarica, Budapest, Schwabenberg, 1888, in Hb. Mus. Brit., ut *F. Schleicheri*!

Typo simillima, sed *petalo superiore alis latioribus* carinam conspicue superantibus obtusissimo, petalo inferiore marginibus latioribus apice obovato, fructibus paululum minoribus vix 2 mm. longis ac latis leviter rugosis.

F. Schleicheri foliorum laciniis latioribus, racemis longius pedunculatis pedicellis longioribus gracilibus breviter bracteatis, floribus saturate roseis, sepalis majoribus, petali superioris haud emarginati alis atropurpureis reflexis nec patulis a *F. Vaillantii* et a *F. Schrammii* differt.

F. officinalis habitu robustiore, bracteis longioribus, floribus sepalisque majoribus, fructibus latioribus retusis truncatisve facile distinguitur.

This pretty species, which is normally a very distinct plant, characterized especially by its deeply coloured flowers and its apiculate fruits borne on long, slender, and shortly bracteated pedicels, has been the subject of much confusion since it was first distinguished by Soyer-Willemet. Hammar, who overlooked Soyer-Willemet's description, seems to have been but slightly acquainted with it; and he failed to recognize the identity of Peterman's shade-grown *F. acrocarpa* from Leipzig, which he described as *F. tenuiflora*, Fries, with the Swiss plants usually distributed by Lagger as *F. Laggeri*, Jordan, and reduced in the Monograph to a variety of *F. Vaillantii*.

It was not till Haussknecht dealt with these plants that Soyer-Willemet's name was re-established and the essential features of *F. Schleicheri* satisfactorily diagnosed in a tabular form in which they are contrasted in detail with *F. officinalis*, *F. Wirtgenii*, and *F. Vaillantii*—the species with which *F. Schleicheri* had been previously hopelessly confused. This elucidation is a careful and accurate piece of work, clearly showing Haussknecht's intimate knowledge of these plants, but his identification of *F. Laggeri*, Jord. with *F. Chavinii*, Reuter, rather than with *F. Schleicheri*, cannot be accepted, as explained at page 68 of "*Fumaria* in Britain." Haussknecht's determination was perhaps influenced by the fact that in Herb. Boissier Lagger's specimen of *F. Laggeri* is *F. Chavinii*.

Even in quite recent years other species have occasionally been mistaken for *F. Schleicheri*, as in the exsiccata Fl. Austro-Hungarica, No. 2903 I, where *F. Schrammii* has been sent out under this name.

According to Haussknecht, authentic material of *F. carinata*, Schur, Enum. Pl. Transsilv. p. 38 (1866), the identity of which is indeterminable from the author's description, belongs to this species, but it is referred to *F. Vaillantii* in Simonkai's Transylvanian Flora.

The distribution of *F. Schleicheri* is shown by Haussknecht to extend from Montpellier and Nice, and from the mountains of Savoy across Central Europe and Russia to the Caucasus and the Altai District of Central Asia. It is also recorded for the Spanish province of Valencia (*cf.* Willkomm,

Fl. Hisp. Suppl. 311 (1893)). It is one of the hardiest species of the genus, growing at an altitude of nearly 6000 feet in the Pennine Alps; and there are specimens in Herb. Kew from Siberia Altaica (Ledebour & Ludwig, as *F. Vaillantii*!).

Janka's *F. supina* has been reduced to a variety of this species as the authentic specimen from Janka at Kew appears to show all the essential features of *F. Schleicheri* and scarcely to differ except in its broadly winged corolla. It is reduced to a synonym of *F. Schleicheri* by Simonkai.

F. Schleicheri × *F. Vaillantii* var. *Chavinii*.

Exsicc. Brunies, Zernez, Ofenpass Gruppe, Graubünden, Switzerland, 1903, in Hb. Zurich, ut *F. Vaillantii* var. *Laggeri*!

Planta robusta, elongata; folia laciniis paululum latioribus quam in *F. Vaillantii* var. *Chavinii* prædita. Racemi 20–30-flori, longi, laxiusculi, pedunculos plane superantes. Bracteæ lineari-oblongæ, acuminatæ, pedicellorum gracilium suberectorum dimidium paulo excedentes. Sepala 1 mm. longa, ovata, longe acuminata; corolla circa 6 mm. longa, læte rosea, petali superioris alis purpureis et ut in *F. Schleicheri* sursum reflexis. Ovaria apiculata; fructûs omnino abortivi.

Exemplaria *Fumariæ Schleicheri* et *F. Vaillantii* var. *Chavinii* in hac regione collecta in herbario Zurich sunt.

41. Fumaria microcarpa, Boissier ex Haussk. in Flora, lvi. 490 (1873).
F. Schleicheri β. microcarpa, Buser in Fl. Orient. Suppl. 27 (1888).

Exsicc. Huet du Pavillon, Erzerum, 1853, in Hb. Boiss., ut *F. parviflora* var. fl. roseis! Maunsell, Van, Asiatic Turkey, 1899–1900, in Hb. Mus. Brit.! Becker, Pl. Astrachanicæ, Sarepta, 1879, in Hb. Mus. Brit., ut *F. Vaillantii*!

This plant, diagnosed as a species with some doubt by Haussknecht from Huet du Pavillon's specimen in Herb. Boissier, is clearly very closely allied to *F. Schleicheri*, as Haussknecht remarks. The resemblance is seen in the foliage, in the dark-tipped flowers with the wings of the upper petal reflexed upwards, and in the sub-rotund, apiculate fruits. But *F. microcarpa* differs in its dwarfer and more erect habit, its much shorter pedicels with relatively long bracts, its smaller and less deeply coloured flowers with more curved inner petals, and its smaller fruits (about 1·75 mm. long and broad).

In some degree *F. microcarpa* may be regarded as intermediate between *F. Schleicheri* and *F. Schrammii*, the latter of which it resembles in its small, apiculate fruit. Its corolla, however, quite lacks the marked dorsal compression, with spreading wings, which characterizes the flowers of *F. Schrammii* and *F. Vaillantii*.

The more recent material collected by Maunsell and Becker, and now at the British Museum, appears to be conspecific with the type of *F. microcarpa* in Herb. Boissier, although these later plants show shorter peduncles and

the Sarepta examples somewhat longer pedicels and larger corollas (up to 5·5 mm. long).

It may thus be concluded apparently that *F. microcarpa* is a local species, more or less generally distributed from Armenia northwards to the basin of the lower Volga.

The exsiccata labelled "*F. microcarpa*, Boiss., Huet du Pavillon, Erzerum, 1853," in Herb. Mus. Brit. (a fragment) and in Herb. Kew are not identical with the type in Herb. Boissier and are referable to *F. Schrammii* and *F. Vaillantii* respectively.

Other Asiatic specimens annotated as similarly named by Haussknecht (Bornmüller, Pl. Anatol. Orientalis, 1890, No. 1877, Amasia!) appear to belong to *F. Vaillantii* var. *conferta*, or (Bornmüller, Pl. Lydiæ et Cariæ, No. 9015, Smyrna!) to *F. Schrammii.*

42. Fumaria indica, sp. nov.

F. Vaillantii var. *indica*, Haussk. in Flora, lvi. 443 (1873); *F. parviflora*, Wight & Arnott, Prod. Fl. Penins. Ind.-Orient. i. 18 (1834), non Lamk.; *F. parviflora* var. *Vaillantii*, Hooker fil. & Thomson, Fl. Indica, i. 258 (1855); *F. parviflora* subsp. *Vaillantii*, Hooker fil. Fl. British India, i. 128 (1872).

Icon. Wight, Illustr. Ind. Bot. i. tab. $\frac{114}{60}$, ut *F. parviflora.*

Exsicc. Hohenacker, Pl. Ind. Or. No. 1488, ut *F. parviflora*! Hooker, No. 206, Behar, ut *F. Vaillantii* (f. *umbrosa*)! Clarke, Nos. 26864 & 26903, Pubna & Beanleah, Bengal, ut *F. parviflora*! Watt, Fl. N.W. Himalayas, No. 852, Pangi, ut *F. parviflora*! Watt, Fl. Gangetic Plain, No. 2156, Bankipore, ut *F. parviflora*!

Fumaria annua, sæpius caulibus crassis *habitu robusto* vel elongato, suberecta vel diffusa, verisimiliter haud scandens. *Folia* vulgo ampla, *fæniculoidea*, plus minusve glauca, foliolis in *lacinias* longas *lineares* vel lineari-oblongas (raro paulo latiores in formis umbrosis) confertas planas acutas fissis 2–4-pinnatisecta. *Racemi* 15–25-flori, floriferi densiusculi, *fructiferi elongati*, laxi, *pedunculos crassos* sæpissime subduplo *superantes*, rarius subsessiles. *Bracteæ* lanceolato-subulatæ, tenuiter acuminatæ, *pedicellos* (vulgo 2–2·5 mm. longos, rarius ad 4·5 mm. elongatos) *erecto-patentes* apice multo incrassatos *subæquantes vel* inferiores nonnunquam *longiores. Sepala circa* 1·5 *mm. longa*, ·50–1 *mm. lata*, *lanceolata* vel ovato-lanceolata, acuminata, plus minusve *inciso-dentata*, rosea, in fructu juniore sæpe persistentia. *Corolla* 5–6 *mm. longa*, *rosea*; *petalo superiore* haud lato *alis roseis* (rarius purpurascentibus) plus minusve *sursum reflexis* carinam superantibus apicemque attingentibus *obtuso*, et calcare longo curvato non adscendente prædito; *petalo inferiore* marginibus patulis apicemque attingentibus obtuso *spathulato*, sæpe libero deflexo; petalis interioribus apice atropurpureis sursum curvatis. *Fructûs mediocres*, 2–2·25 mm. longi, 2·25–2·5 mm. lati, *subrotundo-quadrati*, *subtruncati* et interdum obscure retusi (in statu juniore cum apiculo brevi qui rarissime persistens est),

inferne abrupte angustati, paululum compressi sed valde (præsertim apicem versus) carinati, in sicco apicis foveolis obscuris *rugosi*.

Forma *montana*.

Exsicc. Wallich, No. 1436 B, Kamaon! Collett, No. 457, Simla, ut *F. parviflora*! Aitchison, No. 216, Afghanistan!

Planta humilior, compacta; foliorum minorum laciniis brevioribus crassioribus subcanaliculatis; bracteis pedicellos breviores sæpius multo superantibus.

Fumaria indica per folia vulgo magis decomposita laciniis longioribus prædita, per racemos longiores prope constanter pedunculatos, per sepala plerumque majora, per corollam angustiorem plane curvatam, minus dorso compressam, petali superioris alis sursum reflexis potius quam patentibus, et per fructûs subtruncatos valde carinatos sæpissime majores a *F. Vaillantii*, a *F. Schrammii*, et a *F. parviflorâ* differt.

Præterea *F. Vaillantii* habitu graciliore, foliorum laciniis latioribus, petalo superiore emarginato cum calcare adscendente distinguitur; *F. Schrammii* habitu gracili, racemis paucifloris, floribus petalo superiore emarginato pallidis, fructibus rugulosis apiculatis insuper separanda est; et *F. parviflora* foliorum laciniis vulgo angustioribus canaliculatis, floribus albidis vel roseo-tinctis nec vero roseis, petali superioris alis sæpius externe purpureo-maculatis calcareque semper adscendente etiam notata est.

F. Schleicheri et *F. microcarpa* habitu graciliore, foliorum laciniis multo latioribus relative sparsis, floribus constanter apice omnino atropurpureis, fructibus minoribus rotundatis semper apiculatis longe distant.

F. indica in Indiâ extratropicâ in planitie, in montibus subtropicis et in peninsulæ montibus Nilghiri occurrit, atque in cultis planta communis est; etiam in Scindiâ, in Afghanistan, in Kashmir, et sub montibus Himalaya in Kumaon, in Napaliâ et in Bhotan invenitur.

Ultra regiones Indiæ hæc species in Beloochistan (Duthie, No. 8568, Quetta, in Hb. Mus. Brit., ut *F. parviflora* (abnormalis)!) et in Persiâ (Kotschy, No. 133, Abu Schier, in Hb. Mus. Brit.! Polak, Iter Persicum, 1882, Kaswin, in Hb. Kew, ut *F. Vaillantii*! Kotschy, No. 45, prope Teheran, 1843, in Hb. Kew solo, ut *F. parviflora*!) crescit; etiam ad septentrionem in Turkestan (Regel, Iter Turkestanicum, Baldschuan, 1883, in Hb. Mus. Brit., ut *F. Vaillantii*!), in Songariâ (Krassnow, Fl. Iliensis, 1886, ut *F. Vaillantii*, partim!), in Orenburg (Haussk.) et in Mongoliâ (Meyer, Pl. Mongoliæ, No. 720, Chugutchak!).

The distinctive appearance of this plant, which is now well represented at Kew from numerous Indian localities, was remarked so long ago as 1834 by Wight & Arnott (*l. c.* i. p. 18), who refer it to *F. parviflora* with the remark: "In the Indian plant the flowers are rose-coloured and approach closely to *F. Vaillantii*." Hammar places it under *F. Vaillantii* on account of its flat leaf-segments and obtuse fruits, but notes that its leaf-cutting is much finer

than in the type; and the same peculiar features are recognized by Haussknecht in his diagnosis of *F. Vaillantii* var. *indica*. Like his predecessor, however, Haussknecht does not seem to have remarked the characteristic corolla or to have closely examined the fruits.

It is evident from their labels that some more recent Indian collectors have hesitated what name to apply to this plant, and Aitchison, who found it a common weed on the Afghan frontier, refers it to *F. officinalis*, seemingly distinguishing it from *F. Vaillantii*, which he collected as a rare species in the Kurrum Valley.

F. indica is remarkable for its great altitudinal range, extending from the lowland Ganges basin to at least 9000 ft. in the N.W. Himalayas. As might be expected, examples obtained in the warm regions differ considerably from montane specimens. The form of the plains is usually a large, robust plant, with long leaf-segments, giving it a fennel-like aspect, and frequently elongate pedicels. The hill-plant is naturally dwarfer, and shows relatively small leaves, with thicker and somewhat channelled segments. It also has commonly very short and thick pedicels, much exceeded by the bracts, rather finer flowers, and probably relatively larger sepals. As these differences are such as would be expected to arise solely from the varied environment, the mountain plant has been distinguished merely as a form.

43. Fumaria Vaillantii, Loiseleur in Desvaux, Journ. Bot. ii. 358 (1809), et Notice, 102 (1810); Hamm. Mon. 14 (1857); Haussk. in Flora, lvi. 411 & 441 (1873); Pugsley, Fum. in Brit. 66 (1912). *F. Camerarii*, Bubani, Fl. Pyr. iii. 281 (1901).

Icones. Vaillant, Bot. Paris, tab. 10. fig. 6; Sturm, Deutschl. Fl. i. 62, tab. 15; Reichb. Icon. Fl. Germ. iii. tab. 1. fig. 4452; Hamm. *l.c.* tab. i (f. sepalis latioribus); Clavaud, Fl. Gironde, Pl. 4. fig. 3.

Exsicc. Billot, Fl. G. & G. No. 215 bis! Schultz, Herb. Norm. No. 414! Fl. Exsicc. Carniol. No. 2871!

Hammar's diagnosis of this species is fairly satisfactory, but he does not seem to have appreciated the sparse and long-petioled foliage characteristic of the typical form, which was noticed by the older botanists Vaillant and Loiseleur. It is possible that his description was partly based on examples of the variety *Charinii*, which, judging from British herbaria, appears to be the prevalent if not the only form growing in Scandinavia.

In addition to its omission to emphasize the slender habit and bipinnatisect leaves peculiar to typical *F. Vaillantii*, the Monograph is inaccurate respecting the sepals, which are usually lanceolate instead of subrotund-ovate, and frequently persistent on the young fruit rather than caducous. The flowers of the typical form are normally of a purplish-pink colour; and the ascending spur of the upper petal is a characteristic feature in this species, as

in *F. parviflora*, which is not mentioned in the diagnoses in "*Fumaria* in Britain."

The mucronulus of the young fruit, which sometimes lasts almost to maturity on the living plant, although invisible in the dry state, is also inadvertently unnoticed in "*Fumaria* in Britain." Four forms, based chiefly on the variations of the fruit, are distinguished by Clavaud (Fl. Gironde, 51 (1882)).

F. Vaillantii var. *gracilis*, Knaf in Flora, xxix. 292 (1846), is referred by Haussknecht to a shade-form of the specific type.

β. *conferta*, Haussk. *l. c.* 445.

Exsicc. Heldreich, Isbarte, 1854, ut *F. Vaillantii*!

Herba robusta, *compacta* et satis ramosa; *folia laciniis* obtusiusculis *haud sparsis* 2–3-pinnatisecta. Racemi breves plerumque subsessiles: *pedicelli* haud graciles, *brevissimi* (circa 1 mm. longi). *Corolla minima*, 4–5 mm. longa, *pallide rosea*, petalo superiore alis roseis plus minusve emarginato, calcare ut typi curvato adscendente. *Fructûs minimi*, vix 2 mm. longi et latitudine paulo minores, subrotundi vel subrotundo-obovati, sine apiculo obtusi. Aliter ut in typo.

The type of this variety is represented in Herb. Mus. Brit., and also at Kew, where two good examples exist.

Other exsiccata, as "Bornmüller, Pl. Anatol. Or. No. 1877," referred to *F. microcarpa*, Boiss., apparently agree most nearly with this variety.

γ. *Chavinii*, Rouy & Foucaud, Fl. Fr. i. 181 (1893); Pugsley, *l. c.* 70 (1912). *F. Chavinii*, Reuter, Cat. Pl. Genève, ed. 2, 10 (1861); *F. Vaillantii*, Bab. in Eng. Bot. Suppl. 2877 (1844), partim (fl. roseis); *F. Vaillantii β. Laggeri*, Haussk. *l. c.* 442, nec Hamm. nec *F. Laggeri*, Jord.

Icon. Eng. Bot. Suppl. 2877, partim (fl. roseis), ut *F. Vaillantii*.

Exsicc. Billot, Fl. Exsicc. Cont. No. 3508, ut *F. Chavinii*! Bourgeau, Pl. d'Espagne, No. 2108, ut *F. Vaillantii*! Schultz, Fl. G. & G. 2nd Cent. No. 6, ut *F. Vaillantii*!

Quam typus planta *robustior et erectior*, sæpius *parce ramosa* et nunquam intricato-ramosissima. *Folia* irregulariter *2–3-pinnatisecta*, foliolis quam in typo brevius petiolatis, *laciniis* lineari-oblongis linearibusve, acutis, *confertis* potius quam sparsis. Racemi 10–20- (raro 25-) flori, pedunculos breves superantes. *Pedicelli* quam typi plerumque longiores (3 mm. longi), flexuosi, *suberecti* vel rarius erecto-patentes. Sepala quam in typo minus persistentia. *Corolla* circa 6 mm. longa, *dilute* sed sæpius læte *rosea*, *petali superioris* valde emarginati *alis latissimis*, sæpe subserratis, *roseis* vel raro obscure purpureis. *Fructûs* quam typi sæpe paululum majores, circa 2·25 mm. longi et 2 mm. lati, *subrotundo-ovati*, obtusi vel etiam subretusi, siccitate dense rugosi.

In this variety, which was feebly defined by Reuter but more accurately diagnosed by Haussknecht and by Rouy & Foucaud, the flowers are usually

light rose-coloured with very little, if any darker tinting in the wings of the upper petal. These wings, as well as the margins of the lower petal, are frequently more strongly developed than in the specific type. The fruit of var. *Chavinii*, besides being often rather larger and more rugose than in typical *F. Vaillantii*, differs further in being normally plainly longer than broad.

There is good material of this variety at Kew from the *locus classicus* near Geneva.

F. Vaillantii γ. *ochroleuca*, Knaf in Flora, xxix. 292 (1846), is probably, for the most part, a pale-flowered form of this variety.

δ. *venetica*, var. nov.

Exsicc. Fiori, Béguinot, Pampanini, Fl. Exsicc. Ital. No. 565, Venetia, G. Rigo, ut *F. Vaillantii*!

Planta glauca, ut in var. *Chavinii robusta*, et satis ramosa. *Folia* ampla, irregulariter *2–3-pinnatisecta*, foliolis in lacinias *confertas*, lineari-lanceolatas vel lineares, acutas fissis. Racemi densiusculi, multi-(sub-20-) flori, quam in typo paulo longius pedunculati. *Bracteæ latæ*, lineari-oblongæ, cuspidatæ, *pedicellis* breviusculis (circa 2 mm. longis) *erecto-patentibus* paulo breviores. *Sepala* saltem 1 mm. longa, ·50–·66 mm. lata, *ovato-lanceolata*, plus minusve serrata, nervo dorsali viridiusculo rosea aut roseo-albida, caduca. Corolla ut in var. *Chavinii*, sed *petali superioris alis* angustioribus obscure *purpureis*. *Fructûs* plane *latiores quam longi* (2 mm. longi et 2·25 mm. lati), *subtruncati*, siccitate cum apicis foveolis latis rugosi.

Hæc varietas var. *Chavinii* proxima est, sed pedicellis brevioribus erecto-patentibus, bracteis sepalisque latioribus, corollâ alis angustioribus obscurius coloratâ, fructibus multo latioribus distinguitur.

F. officinalis var. *Wirtgenii* foliorum segmentis latioribus, sepalis corollis fructibusque majoribus conspicue differt.

F. Schleicheri pedicellis gracilioribus et multo longioribus, bracteis minimis, floribus saturate roseis petali superioris alis valde reflexis, fructibus apiculatis rugulosis plane recedit.

F. Vaillantii var. *venetica* in cultis prope Torri del Benaco, Rivoli et Veronam in Venetiâ Italiæ septentrionalis habitat, ubi frequentissime a cl. Rigo ut *F. Laggeri* collecta est. Hæc planta non solum ut *F. Laggeri* et *F. Vaillantii* sed etiam sub nomine *F. Schleicheri* (Fiori, etc., Fl. Exsicc. Ital. No. 566 !) distributa est. Exemplar hujus varietatis, ut videtur, sub nomine *F. Laggeri* prope Weimar (Kastenberg) a Dr. Torge collectum in herbario Kewensi est.

An element of doubt exists as to whether the above three varieties are best placed as such under *F. Vaillantii*, and further study of the group seems desirable, especially as the features of the floral organs can be readily mistaken owing to their small size.

The short racemes of minute flowers seen in var. *conferta* are not unlike those of *F. Schrammii*, which is treated as a separate species, but its fruit characters seem to bring it to *F. Vaillantii*, with which it also agrees in the form of the corolla-spur.

The specific type, peculiar chiefly for the distant and sparing leaflets noted by its earliest describers, looks widely different from well-marked examples of var. *Charinii*, not only in foliage but also in its slenderer and more branching habit, its differently coloured corolla with apparently a more ascending spur, and its distinctly broader fruits. But Haussknecht's remarks that various intermediates are to be found seems correct from the evidence of dried material, and this renders it difficult to define the two forms as distinct species.

The variety *venetica* is most closely related to var. *Charinii*, which it resembles in habit and foliage. These features, combined with its broad fruits, somewhat recall those of *F. officinalis*, and it might be confused with the small-flowered varieties of this species on a cursory examination.

Fumaria Vaillantii is one of the most widely distributed species of the genus, extending from Spain across Europe to the Altai Mountains of Central Asia and to the Indian frontier. In Europe it appears to be less plentiful in the Mediterranean region than in the central portions of the Continent, while in Asia it occurs from the Ægean to Beloochistan, Afghanistan and Kashmir, as well as further north from the Caspian eastwards to Chinese Songaria. Ledebour's specimens at Kew from the Altai Mountains are a mixture of this species and *F. Schleicheri*.

The occurrence of *F. Vaillantii* in North Africa and the Canaries, though reported by both Hammar and Haussknecht, seems open to doubt. It is indeed recorded by Ball for one Moroccan station (Journ. Linn. Soc. xvi. p. 314 (1878)), but Battandier & Trabut (Fl. de l'Algérie, p. 29) remark that they have not seen this species from Algeria, and Munby's Algerian specimens at Kew under this name belong to *F. parviflora*. More recently, however, a Tunisian habitat has been reported by Murbeck (Contr. Fl. Nord-Ouest Afrique, p. 5 (1897)). The examples from the Canaries similarly named, both in Herb. Kew and Herb. Mus. Brit., are referable to *F. parviflora*.

The specific type, originally described by Loiseleur from a French plant, seems to be chiefly found in Western Europe on the calcareous soils of France and Britain. It also grows in the Tyrol (Hb. Kew !), in Albania (Hb. Kew !), in Asia Minor (Hieropolis, Haussk. in Hb. Mus. Brit. !), and in Persia (Teheran, Kotschy, in Hb. Kew !) ; while still further east a similar form, sometimes with broader sepals, prevails, which is represented by the exsiccata Jacquemont, No. 723, Kashmir, in Herb. Kew ! and Aitchison, No. 210, Kurrum Valley, Afghanistan, in Herb. Kew, as *F. parviflora* !

The variety *Charinii*, which is not confined to calcareous ground, appears from herbarium material to be the prevalent form, though not always equally

well marked, of Central and Northern Europe, and is the only form seen from Scandinavia. It also grows in Spain and in France, as well as in Britain, but no undoubted examples of it have been identified from the more eastern parts of the specific range.

44. Fumaria Schrammii, sp. nov.

F. Vaillantii var. *Schrammii*, Haussk. in Flora, lvi. 444 (1873); Rouy & Foucaud, Fl. Fr. i. 181 (1893); *F. parviflora* a. *tenuifolia* aa. *Schrammii*, Ascherson, Verhandl. Bot. Ver. Prov. Brandenburg, v. 221 (1863).

Exsicc. Bourgeau, Pl. d'Espagne, 1850, No. 538, ut *F. Vaillantii*! Filarszky, Fl. Exsicc. Austro-Hungarica, No. 2903I, ut *F. Schleicheri*! Schneider, Iter Balcanicum, 1907, No. 144, Bulgaria prope Varna! Bornmüller, Pl. Lydiæ et Cariæ, No. 9015, Smyrna, ut *F. Schleicheri* var. *microcarpa*! Bornmüller, Pl. Anatol. Or. 1889, Nos. 127 & 135, et 1890, No. 1739! Kotschy, No. 55, Teheran, 1846, ut *F. Vaillantii*!

Fumaria annua, sæpissime *gracilis*, caulibus tenuibus nunc elongatis sparsis nunc ramosissimis compactis prædita, raro petiolis cirrhosis scandens. *Folia* plus minusve glauca, *sæpius ampla*, foliolis tenuibus longe petiolatis in *lacinias lineari-lanceolatas* vel fere lineares (sæpius satis longas) planas acutas fissis 2–3-pinnatisecta. *Racemi breves*, pauci-(6–15-) flori, *breviter pedunculati*, subsessiles *vel* etiam *sessiles*. *Bracteæ angustæ*, lineari-subulatæ, tenuiter acuminatæ, *pedicellis* fructiferis *erecto-patentibus brevissimis* (circa 2 mm. longis) sæpius gracillimis *subduplo breviores*. *Sepala* ·5–·75 *mm. longa*, ·25–·4 *mm. lata*, *sublanceolata*, *inciso-dentata*, albida, facile caduca. *Corolla* 5–5·5 *mm. longa*, *pallide lilacina*; *petalum superius alis lilacinis* vel subpurpureis fere patentibus *emarginatum*, valde dorso compressum, calcare deflexo parum curvato præditum; *petalum inferius* marginibus lilacinis patentibus subtruncatum *spathulatum*; petala interiora apice atropurpurea fere recta. *Fructûs parvi*, 1·75–2 mm. longi et lati, *subrotundi vel subrotundo-ovati*, *cum apiculo* brevissimo persistente *obtusiusculi* vel obtusi, inferne in stipitem angustum obscurum contracti, paulo compressi et plane carinati, in sicco apicis foveolis distinctis *rugulosi*.

β. orientalis, var. nov.

Exsicc. Brotherus, Pl. Caucasicæ, 1881, No. 426, Carthalinia, in Hb. Mus. Brit., ut *F. Vaillantii*! Huet du Pavillon, Erzerum, 1853, in Hb. Mus. Brit., ut *F. microcarpa*! Komarow, Samarkand, 1892, in Hb. Kew, ut *F. asepala*! Gilgit Exped., No. 191, in Hb. Kew!

Herba *robustior*, sæpius basi ramosissima, foliolis quam in typo sparsioribus. Racemi plerumque subsessiles, raro pedunculati. Corolla 5–6 mm. longa, petali superioris valde emarginati alis pallide purpureis. *Fructûs* 2 mm. longi et lati, cum *apiculo distincto* (quam typi longiore) persistente *obtusissimi*, inferne abrupte angustati, quam in typo minus compressi, in sicco *rugosi* potius quam rugulosi.

Hæc species *Fumariæ Vaillantii* cujus formam umbrosam sæpe refert simillima est, sed per foliorum lacinias longiores, per racemos breviores sæpe subsessiles, per corollas lilacinas petali superioris calcare parum curvato, per fructûs minores persistenter apiculatos minus rugosos specifice differre videtur.

F. parviflora, Lamk. habitu robustiore, foliorum segmentis angustioribus plus minusve canaliculatis, bracteis sepalisque latioribus, corollis albidis petalo superiore haud emarginato calcare adscendente, fructibusque valde carinatis rugosis sæpius mucronulatis plane differt.

F. Schrammii Hispaniam (Reuter, Madrid, in Hb. Kew!), Galliam (Bentham, Avignon, in Hb. Kew! Reverchon, Briançon et Vaucluse, in Hb. Kew! Lille, Haussk. Gironde, Rouy & Foucaud), Helvetiam (Graubünden, in Hb. Zurich!), Germaniam (Ascherson & Bænitz, Brandenburg, in Hb. Kew! Thuringen!), Hungariam (Filarszky, No. 2903 I!), Bulgariam (Schneider, Varna!), Macedoniam (Salonika, Haussk.), et Tauriam (Hb. Pallas!) Europæ habitat; in Asiâ etiam Anatoliam (Bornmüller, Smyrna! et Amasia!), Armeniam (Huet du Pavillon, Erzerum —var. *orientalis*!), Transcaucasiam (Brotherus, Carthalinia—var. *orientalis*!), Persiam (Kotschy, Teheran! Bunge, Astrabad—var. *orientalis*!), Turkestan (Komarow, Samarkand—cum var. *orientali*!), Chitral (Relief Expedn., No. 15875, in Hb. Mus. Brit., ut *F. parviflora*!), Gilgit (Expedn. No. 191, in Hb. Kew—var. *orientalis*!), et Kashmir (Winterbottom, in Hb. Kew!).

A compact and densely branched Spanish plant in Herb. Zurich, labelled without date "*F. cæspitosa* Loscos Exsicc. Fl. Arag. n. Castelseras. Leg. Loscos" differs from the original plant sent out by Loscos as *F. cæspitosa* and is a form of *F. Schrammii* var. *orientalis*. The specimen of *F. cæspitosa* in Herb. Boissier also belongs to this form.

It is only after some hesitation that *F. Schrammii* has been described as a species distinct from *F. Vaillantii*, to which it is evidently very closely allied and of which it will be seen to possess almost the same general geographical distribution. While resembling its ally, however, it seems to keep constantly distinct in several particulars, and no intermediate material has come under observation concerning the identity of which any reasonable doubt can be entertained.

Haussknecht, in describing *F. Schrammii* as a variety of *F. Vaillantii*, mentions it as a remarkable plant that may prove to be a separate species, and it seems probable from the notations on Bornmüller's labels that at a later date both he and Ascherson were confirmed in this view.

The variety *orientalis* has been placed under *F. Schrammii* owing to its similarly coloured flowers and persistently apiculate fruit, but the latter organ differs considerably in form from that of the type, and it may prove, when better material of the variety is available, that the two plants are not conspecific.

45. Fumaria asepala, Boissier, Fl. Orient. i. 135 (1867); Haussk. in Flora, lvi. 461 (1873).

Exsicc. Bornmüller, Pl. Anatol. Orient., 1893, No. 1737, Amasia, ut *F. parviflora* f. *erecta* ! Wiedemann, Anatolia, in Hb. Kew, ut *F. parviflora* ! Bornmüller, Iter Persico-Turcicum, 1892–3, No. 3136, Angora, Anatolia, ut *F. parviflora* ! Kotschy, No. 17, Mons Taurus, 1836, ut *F. parviflora* (partim) ! Kotschy, Iter Cilicico-Kurdicum, 1859, No. 41, in Hb. Mus. Brit., ut *F. parviflora* ! Sintenis, Iter Orientale, 1888, No. 282, Mesopotamia ! Stapf, No. 2158, Schiras, 1885, in Hb. Kew !

Fumaria annua, *humilis*, *caulibus* gracilibus *suberectis* haud scandentibus sæpius valde ramosis prædita. Folia glauca, irregulariter 2- (raro 3-) pinnatisecta, *foliolis paulo sparsis in lacinias lineari-oblongas* planas *acutas* basi plus minusve attenuatas fissis. *Racemi* floriferi *brevissimi*, fructiferi tandem paulo elongati, *pauciflori* (6–12-flori), *subsessiles* aut raro brevissime pedunculati. *Bracteæ* lineari-oblongæ, acuminatæ, albidæ, *pedicellos* fructiferos *erecto-patentes* brevissimos (1–2 mm. longos) haud crassos *sæpe superantes* sed nonnunquam breviores. *Sepala absentia* aut rarissime (Sintenis, Iter Or. No. 282, partim) minutissima vix videnda. *Corolla 4–5 mm. longa*, *alba* ; *petalo superiore* valde *dorsum compresso*, *alis latis albis* patentibus vel etiam deflexis ultra carinæ crassæ viridis apicem productis *conspicue emarginato*, atque calcare vix curvato prædito ; *petalo inferiore* lato, carinæ crassæ viridis *marginibus albis patentibus* apicem versus abrupte dilatatis et ultra apicem productis *spathulato-emarginato*, petalum superius extra calcar simulante ; *petalorum interiorum apice* (interdum obscure) *purpureo* ab exteriorum alis *subcelato*. *Fructûs parvi*, circa 2 mm. longi et subæque lati vel paulo angustiores, *subrotundi vel subrotundo-ovati*, paulo compressi et plane carinati, *cum apiculo brevissimo* persistente *obtusi* et inferne paululum angustati, siccitate apice minute sed plane bifoveolati *rugulosi*.

β. *compacta*, Haussk. *l. c.* 461 (1873).

Exsicc. Aucher-Eloy, Herb. d' Orient, No. 4051, Ispahan, ut *F. Vaillantii* ! Kotschy, No. 45, Teheran, 1843, in Hb. Mus. Brit. (non Hb. Kew), ut *F. parviflora* ! Bunge, Iter Persicum, 1859, inter Teheran et Tabriz, ut *F. parviflora* ! Polak, Iter Persicum, 1882, Dauletabad, in Hb. Kew !

Planta *nana*, caulibus curtis suberecta. *Foliorum laciniæ* anguste *oblanceolatæ*, *obtusæ* vel rarius mucronatæ. Racemi constanter brevissimi, vulgo 4–6-flori. Flores typi, sed petalorum interiorum apex viridescens nec purpureus. Fructûs subrotundi, nonnunquam quam in typo paulo majores.

γ. *aprica*, var. nov.

Exsicc. Bornmüller, Iter Persico-Turcicum, 1892–3, No. 3234, Anatolia (Siwas), ut *F. parviflora* f. *aprica* ! Kotschy, Iter Cilicico-Kurdicum, 1859, No. 41, in Hb. Kew, ut *F. parviflora* !

Foliorum laciniæ angustiores, *lineares* nec lineari-oblongæ. Bracteæ quam in typo angustiores. *Corolla* dorso et petalorum exteriorum marginibus angustioribus præsertim apicem versus *rubescens.* Fructûs minimi, 1·75 mm. longi et 1·5 mm. lati, subrotundi. Aliter ut in typo.

Hæc species quæ *Fumariæ Vaillantii* habitum foliaque sed *F. parvifloræ* flores albidos habet non solum calyce abortivo sed etiam petalis duobus exterioribus valde emarginatis altero alterum simulante notabilis est.

F. Vaillantii racemis longioribus pedunculatis, sepalis lanceolatis, corollis majoribus roseis calcare adscendente petaloque inferiore truncato nec emarginato, fructibus sine apiculo persistente rugosis ; *F. parviflora* habitu robustiore, foliorum magis decompositorum laciniis angustioribus vulgo canaliculatis, racemis longioribus, sepalis sæpissime ovatis rarissime obsoletis, corollis vulgo majoribus calcare adscendente petalisque exterioribus haud emarginatis, fructibus sæpissime rugosis valde carinatis insuper distinguitur.

F. Schrammii habitu laxiore, foliorum laciniis et racemis longioribus, sepalis sublanceolatis, corollis majoribus lilacinis petalo superiore solo emarginato satis differt.

F. indica habitu robusto, foliorum laciniis longis angustis, racemis longis pedunculatis, floribus majoribus roseis, petalis exterioribus haud emarginatis, fructibus truncatis rugosis facile separanda est.

This distinct though inconspicuous fumitory, remarkable for its strongly compressed flowers with the outer petals almost equally winged, is widely distributed in Asiatic Turkey and extends eastwards into Persia. The variety *compacta* seems to occur chiefly in the latter country, but it is also recorded by Haussknecht for two Syrian localities.

46. FUMARIA PARVIFLORA, Lamarck, Encycl. Méthod. ii. 567 (1788) ; Hamm. Mon. 16 (1857) ; Haussk. in Flora, lvi. 456 (1873) ; Pugsley, Fum. in Brit. 60 (1912). *F. tenuifolia*, Roth, Catalecta, fasc. ii. 82 (1800).

Clusius' *Capnos cretica floribus candidis fuscâ maculâ* (Hist. Rar. Pl. lib. vi. p. ccix (1601)) appears to be this species. It is cited by C. Bauhin (Pinax, p. 143 (1623)) as a synonym of *Fumaria minor folio oblongo capillaceo*, which, according to A. P. de Candolle (Bull. Hb. Boissier, Tom. iv. 2me Série, No. 3, p. 304 (1904)), is represented in Bauhin's Herbarium by *F. parviflora*.

Icones. Sturm, Deutschl. Fl. i. 62, tab. 16 ; Reichb. Icon. Fl. Germ. iii. tab. 1. fig. 4451 (f. sepalis majoribus) ; Hamm. *l. c.* tab. ii ; Clavaud, Fl. Gironde, Pl. 4. fig. 4.

Exsicc. Heldreich, Herb. Græc. Norm. No. 1206, ut *F. parviflora* f. *umbrosa* ! Wirtgen, Pl. Sel. Rhenan. fasc. iv. No. 159 ! Bourgeau, Pl. Pyr.-Espagnol. No. 389 ! Bourgeau, Pl. d'Espagne, 1851, No. 1014 ! Fiori & Béguinot, Fl. Exsicc. Ital. No. 1051 (ad var. *Symei* accedens) !

Forma *Vivianii.*

F. leucantha, Viviani, Fl. Corsicæ Sp. Nov. Diagn. 12 (1824); *F. parviflora* var. *leucantha*, Clavaud in Act. Soc. Linn. Bordeaux, xxxv. 4e sér. v. 276 (1881), et Fl. Gironde, 52 (1882), ex parte.

Exsicc. Pichler, Fl. Exsicc. Austro-Hungarica, No. 87, Spalato, ut *F. parviflora*! Reverchon, Pl. de Sardaigne, No. 91, ut *F. parviflora* (f. fol. laciniis latioribus)!

Fructibus obtusis nec acuminatis nec emarginatis a typo differt.

In the case of this species Hammar's diagnosis is generally accurate, but he appears to have overlooked the characteristic broad bracts, which he describes as linear, as well as the normally obtuse but not emarginate upper petal, with its purple blotch on the outer or lower side of the wings.

The form regarded as the specific type, in accordance with the general view of authors, is the more robust plant, with laxer and less glaucous foliage, whiter and somewhat narrowly winged corollas, and shortly mucronulate fruits, as described in "*Fumaria* in Britain" (*F. parviflora* var. *leucantha*, Clavaud, *l. c.*, excl. forma *Vivianii*). The rotundate, ascending spur common to all the forms of the species is not mentioned, through inadvertence, in that description. It may be added that the leaves in this species are commonly 3–4 rather than 2–3-pinnatisect, and the corolla is not often more than 5 mm. in length.

! Flores albi, vix roseo-tincti; sepala sæpissime albida; petali superioris alæ quam in typo angustiores.

β. Symei, Pugsley, *l. c.* 65 (1912).

F. Vaillantii, Bab. in Trans. Bot. Soc. Edin. i. 36 (1844); et Eng. Bot. Suppl. 2877 (1844), ex parte, non Lois.

Icon. Eng. Bot. Suppl. 2877, ut *F. Vaillantii* (partim—f. flor. albis).

Exsicc. Reverchon, Pl. de l'Andalousie, No. 557, ut *F. parviflora*!

In addition to the short leaf-segments, relatively large sepals, and finally retuse fruits characteristic of this variety, it may be distinguished by its racemes, which, both in flower and in fruit, are normally laxer than in the other forms of this species.

Other examples collected in Spain (Bourgeau, Pl. d'Espagne, 1850, No. 537!), in Morocco (Hooker, Casa Blanca, 1871, in Hb. Kew!), and in the Canaries (Lowe, No. 21bis, Orotava, 1858, in Hb. Mus. Brit., ut *F. parviflora* fl. albis!) are closely related to, if indeed separable from this variety.

γ. latisecta, Haussk. *l. c.* 460 (1873).

Exsicc. Schimper, No. 110, Mt. Sinai, 1835, ut *F. parviflora*! Macdonald, Arabia Petræa, 1849, in Hb. Kew, sub *F. parviflora*!

Planta satis robusta, suberecta, haud scandens; *folia* vix glaucescentia, *ampla, laciniis* linearibus vel oblongo-linearibus, *1–2 mm.* (ad 3 mm. ap. Haussk.) *latis, fere planis*, obtusis obtusiusculisve prædita. *Racemi* sessiles,

densi (etiam fructiferi), quam folia opposita multo *breviores*; bracteæ pedicellos brevissimos (circa 1 mm. longos) plane superantes. Corolla 4·5–5 mm. longa, albida; petalo superiore anguste alato. *Fructûs* parvi, vix 2 mm. longi ac lati, subrotundi, obtusi vel subretusi, brevissime apiculati, siccitate *sublæves*. Aliter ut in typo.

This variety, which is well represented at Kew, is notable for its ample foliage with broad and nearly flat leaf-segments, for its very short and dense racemes, and for its nearly smooth instead of rugose fruits.

Tommasini's specimen from Trieste, in Herb. Boissier, included in Haussknecht's citations for this variety, shows poor flowers and fruits, but has the aspect of a form of *F. Vaillantii*, as labelled. A few other European exsiccata, as "Reverchon, Pl. de Sardaigne, No. 91," approach this variety in foliage.

δ. *persica*, var. nov.

Exsicc. Sintenis, Iter Transcaspico-Persicum, 1900–01, No. 1548, ut *F. asepala*! Bornmüller, Iter Persicum alterum, 1902, No. 6112, Persia borealis, ut *F. parviflora*! Kotschy, No. 314, Schiras, 1842, ut *F. parviflora*! Fl. Baluchistan, No. 3521, ut *F. parviflora* (partim—pl. fl. albis)! Kotschy, No. 17, Mons. Taurus, 1836, in Hb. Kew, ut *F. parviflora* (partim)! Postian, Pl. Mont. Syriæ borealis, Aintab, in Hb. Mus. Brit., ut *F. asepala*!

Planta robusta, ramosior, haud scandens; *folia* plus minusve glauca, *ampla*, *laciniis linearibus* vel oblongo-linearibus (raro plus 1 mm. latis), *confertis*, *brevibus*, crassiusculis, subcanaliculatis, acutis subacutisve prædita. Racemi sæpissime sessiles, breves, floriferi densi, fructiferi paulo elongati; bracteæ pedicellos brevissimos (circa 1 mm. longos) multo superantes. *Sepala absentia aut minuta* (circa ·5 mm. longa), triangulari-ovata, acuminata, albida. *Corolla minima*, 4–4·5 mm. longa, alba; petali superioris alis angustis vulgo sine maculâ purpureâ; petalorum interiorum apice purpureo vel viridiusculo. *Fructûs* 2 mm. longi et paululum latiores, subrotundo-obovati, *obtusissimi* vel subtruncati, obscure *brevissime apiculati*, in sicco *rugosi*.

Hæc varietas quæ per foliorum amplorum lacinias breviores confertas et per fructûs obtusissimos a typo longe distat varietati *latisectæ* similis est, sed foliorum laciniis brevioribus angustioribus, sepalis absentibus vel minutis, corollâ minimâ, fructibusque obtusissimis rugosis potius quam sublævibus satis differre videtur.

!! Flores tandem roseo-tincti; sepala rosea; petali superioris alæ sæpius latiores.

ε. *glauca*, Clavaud in Act. Soc. Linn. Bordeaux, xxxv. 4 sér. v. 277 (1881), et Fl. Gironde, 53 (1882); Nicotra, Le Fum. Ital. 69 (1897). *F. glauca*, Jordan, Pugillus, 8 (1852)?

Exsicc. Schultz, Herb. Norm. No. 415 ter, ut *F. parviflora*! Bourgeau, Env. de Toulon, No. 18, in Hb. Kew, ut *F. parviflora*! Kralik, Pl. Tunet.

1854, No. 8, in Hb. Mus. Brit., ut *F. parviflora*! Bornmüller, Iter Persico-Turcicum, 1892–3, No. 2030, Persia borealis, ut *F. parviflora*!

Planta quam typus *humilior*, haud scandens. *Folia* valde glauca, *laciniis anguste linearibus, brevibus*, canaliculatis, sæpe crassiusculis. Racemi floriferi densi; flores quam in hujus speciei aliis formis magis patentes. *Corolla* usque ad 5 mm. longa, sæpius *læte roseo-tincta*; *petali superioris alæ* quam in typo latiores, præsertim *apicem versus dilatatæ*; petalo inferiore sæpe subtruncato et libero deflexo. *Fructûs* vix 2 mm. longi latique, subrotundi, *obtusiusculi brevissime apiculati*, rarius subrotundo-ovati acutiusculi. Aliter ut in typo.

The corolla of this pretty variety differs somewhat in shape from that of the other forms of this species, and at the time of flowering is generally less erect in the raceme.

Plants occur (*cf.* Bourgeau, Pl. d'Espagne, 1849, No. 22, in Hb. Mus. Brit.!) having the habit and flowers of var. *glauca* with the more attenuate fruit of var. *acuminata*.

ζ. *acuminata*, Clavaud, *ll. c.* 277 et 53 (1881 et 1882); Pugsley, *l. c.* 64 (1912).

Icon. Smith, Eng. Bot. 590, ut *F. parviflora*.

Exsicc. Schultz, Herb. Norm. Nos. 415 & 415 bis, ut *F. parviflora*! Sintenis, Iter Trojanum, 1883, No. 301, Kenkoei, ut *F. parviflora*!

Planta ut var. *glauca humilis*, haud scandens. *Folia* intense glauca, *laciniis* tenuiter linearibus vel *subcapillaceis* canaliculatis. Racemi floriferi densiusculi. *Corolla relative majuscula*, 5–6 mm. longa, tandem roseo-tincta; petalorum exteriorum margines quam in typo paululum latiores. *Fructûs* 2·25–2·5 mm. longi et 2 mm. lati, *subrotundo-ovati*, cum apiculo brevissimo persistente *acutiusculi vel acuminati*, in sicco apicis foveolis fere obsoletis rugosi.

This variety is notable not only for its more acuminate fruits but for its very fine, almost capillary leaf-segments; and its flowers are somewhat larger than those of any other form of the species.

η. *sinaitica*, Haussk. *l. c.* 460 (1873).

Exsicc. Boissier, Jardin du Sinai, Arabia Petræa, 1846, in Hb. Boissier!

Planta *nana*, vix 4 cm. alta, satis ramosa. *Folia* intense glauca, inferiora caules fere æquantia, *laciniis obtusis brevissimis* (superioribus vix 1 mm. longis) prædita. *Corolla roseo-tincta*. Fructûs ut in typo.

This seems to be a very rare plant, known only from Mt. Sinai.

θ. *indicoides*, var. nov.

Exsicc. Bornmüller, Iter Persico-Turcicum, 1892–3, No. 9, Persia australis (Farsistan), ut *F. parviflora*, transiens ad *F. segetalem*, Hamm.! Bagdad, Samaur, (ex Herb. Schäfli) in Hb. Kew! Russell, Aleppo, in Hb. Mus. Brit.!

Planta internodis longis robusta, suberecta vel diffusa. *Folia* glauca, *laciniis linearibus* vel oblongo-linearibus, breviusculis, acutiusculis, canaliculatis. *Racemi* etiam floriferi *haud densi*; bracteæ pedicellos crassos breves (circa 1·5 mm. longos) plane superantes. Sepala 1–1·5 mm. longa, subrotundo-ovata, acuminata, dentata. *Corolla* vix 5 mm. longa, *dilute rosea*; *petali superioris alis* latis omnino *roseis*; *petalorum interiorum apice viridiusculo* potius quam purpureo. *Fructûs* 2–2·25 mm. longi et lati, *subrotundo-obovati, obtusissimi*, obscure brevissime apiculati, præsertim apicem versus *conspicue carinati*, in sicco apicis foveolis obscuris rugosi.

Hæc varietas per flores sine apice atropurpureo obscure roseos et per fructûs majores obtusissimos apicem versus conspicue carinatos a *F. parviflora* aliis formis separanda est et transitum ad *F. indicam* denotare videtur, sed foliorum laciniæ breviores, racemi subsessiles et præsertim corolla brevior alis patentibus calcareque rotundato adscendente prædita ejus cum *F. parviflorâ* propinquitatem certissime monstrant.

An example in Herb. Mus. Brit. (Haussknecht, Iter Orient. Schiras, ut *F. parviflora* !), with small rosy-white flowers and obscure sepals, seems intermediate between this variety and δ. *persica*.

Hammar's variety *segetalis* (Mon. p. 17), distinguished by sepals one fourth as long as the corólla and as broad as its tube, has been shown under *F. Reuteri* to belong to that species and not to *F. parviflora*.

Haussknecht, who does not seem to have seen Lange's specimen on which this variety was founded, regards it as a form of true *F. parviflora*, and cites for it several fresh exsiccata, of which those from Segura de la Sierra, Murcia, and from Aintab have been examined, and are found to resemble closely Clavaud's variety *glauca*.

The original specimens of *F. cæspitosa*, Loscos (Loscos, Series Exsicc. Fl. Aragon, Centuria prima, No. 2) are referred by Haussknecht in Oesterr. Bot. Zeit. xxvii. p. 50 (1877), to *F. parviflora* f. *erecta*, Haussk. This plant is admitted as a distinct species in Willkomm & Lange's Fl. Hispanica, iii. p. 884, but in their Supplement (p. 311) it is reduced to a variety of *F. Vaillantii* with the remark "vix varietas dicenda." The example in Herb. C. Bailey is an early-flowering form of *F. parviflora*, probably identical with the material seen by Haussknecht, but as already noticed under *F. Schrammii*, the specimens in Herb. Boissier and Herb. Zürich are quite different, so that some confusion presumably occurred among the plants sent out under this name. The original description by Loscos and by Willkomm & Lange point, on the whole, to a form of *F. Vaillantii*.

Another plant allied to *F. parviflora* is *F. Trabuti*, Battandier & Trabut, Fl. de l'Algérie, i. 29 (1888), of which no material has been seen. It is described as follows:—

Fumaria verisimiliter annua caulibus curtis robustis. Folia inferiora

multa, conferta, angusta, oblonga, laciniis curtis lanceolatis paulo latis haud canaliculatis prædita, eis sectionis *Petrocapnos* quarumdam specierum similia; folia superiora ut in *F. parviflorâ*. Flores satis magni, 6 mm. longi, albi; sepala lata. Fructûs magni, obtusi, apiculati. Habitat in provinciâ Oran Algeriæ.

A further variety of *F. parviflora*, established as *β. macrocarpa* in J. Perez Lara's Florula Gaditana, pars 5, p. 64, in Anales de Hist. Nat. Soc. Espagn. (1898), is said to have rosy flowers and fruits two or three times as large as in the type.

Like *F. Vaillantii*, *F. parviflora* is one of the most widely spread members of the genus, having a somewhat similar range extending from Spain across Europe to Afghanistan and Beloochistan. It is clearly, however, a more southern species and one more impatient of cold. In Europe it is commonest in the Mediterranean region, and does not occur so far to the north and east as *F. Vaillantii*, being little known in Russia except in the Crimea (Herb. Pallas). Similarly in Asia it is absent from the districts between the Caspian and Mongolia, where *F. Schleicheri*, *F. Vaillantii*, and *F. Schrammii* have all been found. On the other hand, it is known from all the countries of North Africa from Morocco to Egypt, as well as from the Canaries.

The commonest form of this polymorphic plant is no doubt the specific type, varying considerably in the form of its fruit and connected with most of the varieties by numerous intermediate forms. This occurs from the Canaries, Morocco and Spain eastwards to Syria and Mesopotamia. The variety *Symei* is known from Britain and Spain, and probably grows elsewhere; var. *acuminata* is mostly a plant of Western Europe, but has been collected also in Asia Minor; var. *glauca* is pre-eminently a Mediterranean form, growing on the African as well as the European side and extending into Syria and Persia. Haussknecht's varieties *latisecta* and *sinaitica* are both Arabian forms, probably collected in natural habitats, and examples which he obtained in the desert near Bagdad seem almost identical with var. *latisecta*, which Haussknecht records also for Dalmatia. The two remaining varieties, both characterized by very obtuse fruits though dissimilar in other respects, are the most eastern forms of the species. The variety *persica* appears to be a prevalent form in Persia, growing also in Beloochistan, Syria, and the Taurus Mts.; var. *indicoides*, which is presumably a rarer form, ranges, so far as is known, from Syria across Mesopotamia to Southern Persia.

RUPICAPNOS.

Rupicapnos, Pomel, Mat. Fl. Atlant. 16 (1860); Nouv. Mat. Fl. Atlant. i. 240 (1874). *Fumaria* sect. *Petrocapnos*, Cosson & Durieu in Bull. Soc. Bot. France, ii. 305 (1855); Willkomm & Lange, Fl. Hisp. iii. 878 (1880); Cosson, Comp. Fl. Atlant. ii. 80 (1883–1887).

Plantæ *perennes* caudice decumbente *caulibusque brevissimis aut* rarius *annuæ nanæ* caule suberecto brevissime ramoso. Folia in speciebus perennibus pleraque subradicalia, in omnibus semper longe petiolata, *foliolis breviter petiolatis* vel subsessilibus 1–2-pinnatisectis vel inciso-flabellatis irregulariter pinnata (*R. muricariâ* exceptâ); segmenta secundaria decurrentia; petioli nunquam cirrhosi. *Inflorescentia pedicellis* fructiferis gracilibus *elongatis* tandem deflexis *racemoso-corymbiformis*. Bracteæ pedicellis fructiferis multoties breviores. *Corolla uni- vel inæque bicalcarata;* petalorum exteriorum margines apicem versus in statu juvenili jam multo explicati ut in genere *Sarcocapnos*; *petalum superius* subplanum potius quam semi-cylindricum, calcaratum, superne gibbum format qui apicem vix attingit et margines sæpissime patentes in limbum latum interdum dilatatos nunquam purpureos *habet* sed *non alas in jugum laterale productas*; *petalum inferius* inferne gibbum apicem vix attingentem marginibus patentibus circumdatum formans *sæpe* basi ipsâ *breviter calcaratum* vel saccatum fit; petalorum interiorum nervus medius apicem versus sæpe conspicue alatus est. Floris characteres reliqui ut in genere *Fumariâ*. *Fructus* monospermus, indehiscens, nuciformis, semper mucronatus vel rostratus sed *haud* apice *bifoveolatus* (sine rimis in mesocarpio) est; exocarpium tuberculis rugosum; *endocarpium omnino ad mesocarpium adhærens*; *semen apice rotundatum* vel paulo depressum, sine rugâ longâ infra micropylam.

Perennial, or more rarely annual plants, always with short stems, growing in rock-clefts. Inflorescence corymbiform with pedicels which lengthen in fruit and become deflexed so as to carry the seeds to the cavities of the rocks on which the plants grow. Lower petal often shortly spurred. Fruit without apical pits.

In the perennial species of *Rupicapnos* the root is quickly elongated and the leaves are at first all radical, forming a close tuft. After the first year, the plant develops a thick, branched, decumbent rootstock, from which arise very short, branched stems, bearing long-petioled leaves and subterminal corymbiform racemes. The foliage is usually less decompound than in *Fumaria*, and the leaf-segments are much more shortly petioled and more decurrent, the secondary petioles never being cirrhose. The flower-buds of all the species resemble those of the genus *Sarcocapnos* rather than *Fumaria*, having well developed margins to the two outer petals, while the spur of the upper one is very small. This spur, as seen in perfectly developed flowers, varies greatly in different species and is of importance for affording specific

characters, but in shade-grown plants of some species it does not always attain its normal development. So far as can be judged from the limited material examined, the corolla is more uniform in the species of this genus than in *Fumaria*, and shows little tendency to cleistogamy.

CONSPECTUS OF SPECIES.

Section I. MURICARIA.

Suberect annual plants with cauline leaves and few-flowered racemes. Flowers small or rather so, 4–8 mm. long, white; outer petals rarely dilated apically into a spreading, suborbicular limb, little longer than the inner petals, which are tipped with dark purple. Fruit very large, or at least of moderate size.

* Leaves 2–trisect. Racemes subsessile.

1. *R. muricaria.* Flowers 7–8 mm. long; lower petal spathulate. Fruit very large, subrotund, marginally muricate, with long, large beak.

** Leaves 2–pinnatisect. Racemes peduncled.

2. *R. delicatula.* Leaves with multifid leaflets. Flowers 4 mm. long; outer petals apically dilated. Fruit subglobose, muricate, apiculate.
3. *R. longipes.* Leaves deltoid. Flowers 6–8 mm. long; lower petal dilated into a suborbicular limb. Fruit very large, subrhomboid, muricate, with large, broad beak. Pedicels very long.
4. *R. prætermissa.* Leaves deltoid. Flowers 6–7 mm. long; lower petal spathulate. Fruit rather large, ovate-elliptical, finely rugose, with compressed beak.
5. *R. sublævis.* Leaves oval, with closer leaflets. Flowers . . . Fruit of moderate size, narrowly obovate, finely rugose, with small beak.

Section II. SARCOCAPNOIDES.

Decumbent perennial plants with quinate-pinnate, mostly subradical leaves and many-flowered racemes. Flowers small or rather so, 4–10 mm. long; outer petals each apically dilated into a spreading, suborbicular limb, distinctly longer and broader than the inner petals, which are tipped with dark purple. Fruit small.

6. *R. sarcocapnoides.* Lobes of leaflets elliptical. Flowers 4–5 mm. long, white; lower petal not saccate.
7. *R. Reboudiana.* Lobes of leaflets cuneiform. Flowers 9–10 mm. long, rosy-white lower petal saccate.

Section III. TRIPTERYX.

Decumbent perennial plants with 2–3-pinnatisect, mostly subradical leaves and many-flowered racemes. Flowers small or rather so, 4–10 mm. long, whitish and more or less tinted with yellow; outer petals more or less apically dilated into spreading, suborbicular limbs, little longer than the inner petals, which are conspicuously winged and at most obscurely tipped with dark purple. Fruit small to rather large.

* Flowers 4–5 mm. long; lower petal not saccate.

! Lower petal gradually dilated apically.

8. *R. numidica.* Leaves subdeltoid with remote leaflets. Spur of upper petal very small, straight. Fruit oblong-obovate.

9. *R. Cossonii.* Leaves oval with closer leaflets. Spur of upper petal rather large, curved. Fruit subrotund-obovate.

!! Lower petal more abruptly dilated apically; spur of upper petal moderate.

10. *R. tenuifolia.* Leaves oblong, with finely cut leaflets. Wings of inner petals not exceeding outer petals. Fruit subrotund.

11. *R. caput-plataleæ.* Leaves subdeltoid, with remote, cuneiform segments. Wings of inner petals much exceeding outer petals. Fruit elliptical.

** Flowers 6–10 mm. long; lower petal subsaccate.

12. *R. erosa.* Leaves oblong; leaflets with broad segments. Spur of upper petal rather long. Fruit subrotund, sometimes rather large.

Section IV. CALLIANTHOS.

Decumbent perennial plants, usually larger than those of the other sections, with 2–3-pinnatisect, mostly subradical leaves and many-flowered racemes. Flowers large, 12–16·5 mm. long, white or pale purple; outer petals never apically dilated into a spreading, suborbicular limb, little exceeding the inner petals, which are tipped with dark purple: lower petal saccate. Fruit very large to moderate in size.

Subsection AFRICANÆ.

Lobes of leaf-segments relatively narrow. Flowers white.

13. *R. africana.* Leaves subdeltoid, with narrowly oblong lobes. Sepals ovate-lanceolate. Spur of upper petal very long. Fruit of moderate size, obovate-elliptic, shortly mucronate.

14. *R. decipiens.* Leaves deltoid, with subelliptical lobes. Sepals oval. Spur rather long. Fruit very large, obovate, shortly mucronate.

15. *R. platycentra.* Leaves deeply divided, with small, obovate lobes. Sepals orbicular. Spur rather long. Fruit . . . oval-elliptic.

16. *R. cerefolia.* Leaves more decompound, with small, narrow lobes. Sepals ovate-lanceolate. Spur long. Fruit of moderate size, elliptic, acuminate.

17. *R. speciosa.* Leaves with broadly oblong lobes. Sepals orbicular. Spur short. Fruit . . . lanceolate-obovate, long-mucronate.

Subsection POMELIANÆ.

Lobes of leaf-segments broad. Flowers pale purple.

18. *R. Pomeliana.* Leaf-segments subimbricate, with rounded lobes. Sepals orbicular. Spur very short. Fruit rather large, subrotund-obovate.

19. *R. oranensis.* Leaf-segments with broad lobes but not imbricate. Sepals small, ovate. Spur long. Fruit large, oval-obovate.

20. *R. ochracea.* Leaf-segments not imbricate, with small, obovate lobes. Sepals small, lanceolate. Corolla smaller, with long spur. Fruit narrow, oblong.

Sectio I. MURICARIA.

Plantæ annuæ, suberectæ. Racemi pauciflori. Flores parvuli, rarius parvi, 4–8 mm. longi, albi; petalis exterioribus quam interiora sæpius fere recta apice plane alata atropurpurea vix longioribus, marginibus eorum apice subpatentibus nonnunquam in limbos suborbiculares dilatatis; stylus

malleiformis lobis divaricatis (an semper ?). Fructûs maximi ad modici, sæpius valde compressi, pericarpio quam in sectionibus sequentibus verisimiliter tenuiore præditi.

1. Rupicapnos muricaria, Pomel, Nouv. Mat. Fl. Atlant. i. 245 (1874). *Fumaria muricaria*, Batt. & Trabut, Fl. d'Alger. i. 26 (1888). (Pl. **14**, fig. 1.)

Exsicc. Chevallier, Pl. Saharæ Alger. 1902, No. 397, Ghardaia, ut *Fumaria longipes* !

Rupicapnos, ut videtur, annua, radice longâ et caule suberecto (4–8 cm. alto) brevissime ramoso prædita. Cotyledones in statu foliaceo maximæ, circa 4 cm. longæ, lineari-oblanceolatæ, tenuiter acuminatæ, diu persistentes. *Folia* caulina haud crassa, omnia longissime petiolata, cum petiolo 5–7·5 cm. longa, *deltoidea*, foliolis subtrifidis longiuscule petiolatis et segmentis secundariis in *lacinias parvas oblongas vel lanceolatas* longe mucronatas vel *fere aristatas* irregulariter multifidis *trisecta*. *Racemi* corymbiformes, *pauci-* (2–5-) *flori*, brevissime pedunculati vel *subsessiles*, *foliis plus duplo breviores*. *Bracteæ* 1–2 mm. longæ, *subulatæ*, tenuiter acuminatæ ; *pedicelli fructiferi filiformes*, apice vix incrassati, flexuosi, *ad* 15 *mm. longi*. *Sepala parva*, *circa* 1 *mm. longa*, ·5–·6 *mm. lata*, *ovata* vel lanceolata, vix peltata, acuta, *parce dentata* vel subintegra, albida. *Corolla* 7–8 *mm. longa*, præter carinas virides *alba* vel leviter roseo-tincta ; *petalo superiore* apice marginibus latiusculis subpatentibus *anguste oblongo*, *truncato* obtusissimo vel etiam retuso, *calcare* gracili *longo* deflexo, [nectario flexuoso longissimo ap. Pomel] ; *petalo inferiore* apice marginibus latiusculis patentibus *spathulato*, *obtusissimo*, *basi* verisimiliter *obscure saccato* ; *petalis interioribus* paulo sursum curvatis apice *plane alatis atropurpureis*. Stylus malleiformis. *Fructûs maximi*, sine rostro 2·75–3 mm. longi et 3–3·25 mm. lati, *subrotundi* sed latiores quam longi, *cum rostro magno* 1·5–2 mm. longo quadrangulato-*subulato obtusissimi* et inferne subtruncati, valde compressi et acute carinati, pericarpio satis tenui prædîti, in sicco (sine apicis foveolis) *carinam versus* subregulariter grosse et acute tuberculato-rugosi vel *muricati*, infra rostrum et ad fructûs medium vix tuberculati.

Hæc *Rupicapnos* distinctissima per folia trisecta, per racemos corymbiformes subsessiles paucifloros et præsertim per fructûs maximos grosse rostratos carinam versus muricatos ab generis omnibus aliis speciebus facile dignoscitur.

R. muricaria Metlili (ap. Pomel), Ghardaiam et forsan alios locos in regione Saharæ Algeriensis habitat, ubi in fissuris rupium crescit.

This species is unique in the genus on account of its trisect leaves, its subsessile, 2–5-flowered corymbs, and its very large, long-beaked fruits, muricate only towards their margins. Chevallier's exsiccata, which form the basis of the foregoing description and from which the accompanying plate is

drawn, were presumably referred to *Fumaria longipes*, Cosson, owing to that plant being originally described as an annual with somewhat similar flowers. Their agreement with the account of *R. muricaria* furnished by Pomel is unmistakeable.

[2. Rupicapnos delicatula, Pomel, Nouv. Mat. Fl. Atlant. i. 246 (1874); n. v. *Fumaria delicatula*, Batt. & Trabut, Fl. d'Alger. i. 26 (1888).

Rupicapnos annua. Folia *foliolis multifidis* in *lobos* sæpius parvos *obovatos* vel oblongos, obtusos vel subacutos, divaricatos fissis *verisimiliter 2-pinnatisecta*. Racemi corymbiformes, breves sed *floribus pluribus quam in R. muricariâ* præditi. *Bracteæ lanceolatæ*, acuminatæ; *pedicelli capillares*, apice incrassati. *Sepala lanceolata, denticulata*. *Corolla minima*, 4 *mm. longa, albida*; *petalis exterioribus apice dilatatis, calcare* superioris *brevissimo* recto paululum attenuato; nectario brevissimo; petalis interioribus, ut videtur, apice purpureis. *Fructûs subglobosi*, leviter *apiculati*, parum compressi, siccitate acute tuberculato-rugosi vel *muricati*.

R. delicatula rupes calciferas ad Ksar-el-Maïam Algeriæ australis habitat.

This plant appears to differ considerably from the other known annual species, and some of its features recall *R. tenuifolia*. Judging from Pomel's knowledge of these plants, however, it is unlikely that he would have confused it with a perennial species, although his diagnosis makes no mention of its different habit; and the species has therefore been provisionally adopted.]

3. Rupicapnos longipes, Pomel, Mat. Fl. Atlant. 16 (1860); Nouv. Mat. Fl. Atlant. i. 245 (1874). *Fumaria longipes*, Coss. & Dur. in Bull. Soc. Bot. Fr. ii. 305 (1855); Batt. & Trabut, Fl. d'Alger. i. 26 (1888); *F. numidica* var. *longipes*, Coss. Comp. Fl. Atlant. ii. 82 (1883–1887). (Pl. **15**, fig. 1.)

Exsicc. Balansa, Pl. d'Algérie, 1853, Mnechounès, near Biskra, in Hb. Mus. Paris (partim), ut *F. longipes*!

Rupicapnos, ut videtur, annua, radice longâ et caule suberecto (5–10 cm. alto) brevissime ramoso prædita. *Folia* caulina, haud crassa, omnia longe petiolata, cum petiolo 5–12 cm. longa, *deltoidea*, foliolis infimis breviter petiolatis, reliquis subsessilibus, et segmentis secundariis in *lacinias oblongas* lanceolatasve *acutas* irregulariter fissis *2-pinnatisecta subquinata*, vel primaria simpliciora pinnata. *Racemi* corymbiformes, *pauci*-(3–8-) *flori*, cum pedunculo (ad 35 mm. longo) *foliis multo breviores*. *Bracteæ* 1–2 mm. longæ, *ovales*, acutæ, subintegræ; *pedicelli fructiferi fere filiformes*, apice incrassati, flexuosi, longissimi (*usque ad* 60 *mm. longi*). *Sepala circa* 2 *mm. longa*, 1 *mm. lata*, *ovalia*, peltata, acuta, *subintegra* vel leviter crenato-dentata, nervo dorsali viridiusculo alba. *Corolla*

6–8 *mm. longa, alba* ; *petalo superiore* apice marginibus latis subpatentibus ultra carinæ apicem productis *obovato-oblongo, truncato* vel retuso, carinâ crassâ, viridi vel purpurascente, *calcare longiusculo* deflexo; *petalo inferiore* (quam superius latiore) apice *marginibus* latis patentibus *in limbum suborbicularem* obtusissimum vel retusum abrupte *dilatatis* et carinâ viridi prædito, *basi subsaccato* ; *petalis interioribus* fere rectis apice *plane alatis atropurpureis*. *Fructûs maximi*, sine rostro 3·5 mm. longi, 3 mm. lati, *subrhomboidei, cum rostro magno* (1 mm. longo), *latissimo*, striato, quadrangulato, compresso *subacuti* et inferne attenuati, conspicue compressi et acute carinati, pericarpio satis tenui præditi, siccitate *præter rostrum* omnino grosse et acute tuberculato-rugosi vel *muricati*.

R. longipes in fissuris umbrosis rupium ad Mnechounès, prope Biskram, ad Elkantaram (Cosson) et in Montium Aurasiorum regione montanâ inferiore prope Beni Souik (Cosson) in provinciâ Constantinâ Algeriæ invenitur.

This species was originally described by Cosson & Durieu (*l. c.*) as a *Fumaria*, and was founded on exsiccata collected by Balansa near Biskra and by Gallerand near Beni Souik, both in the southern part of the province of Constantine. The annual nature of the plant and its floral characters were defined in the original description, but no mention was made of its peculiar fruit ; and later, in the Compendium, it was reduced by Cosson to a variety of his perennial *F. numidica*. Pomel admitted it as a species, although the actual plant was unknown to him.

The sheet of Balansa's Biskra plant named *Fumaria longipes* in Herb. Mus. Paris contains four specimens, two of which agree with Cosson's diagnosis, so far as it goes, and possess the remarkable fruit described above. From these the foregoing description and the accompanying figure have been taken. The other two specimens, which are not alike, possess somewhat similar foliage but are clearly shown by their widely different fruits to be specifically distinct. These are separated under the names of *R. prætermissa* and *R. sublævis*.

4. RUPICAPNOS PRÆTERMISSA, sp. nov. (Pl. **14**, fig. 2.)

Exsicc. Balansa, Pl. d'Alger. 1853, Mnechounès, near Biskra, in Hb. Mus. Paris (partim), ut *Fumaria longipes* !

Rupicapnos annua, *habitu foliisque R. longipedis* sed, ut videtur, planta minor. *Racemi* corymbiformes, *pauci*-(3–5-)*flori*, cum pedunculo (sub-20 mm. longo) *foliis plus duplo breviores*. *Bracteæ* 1–1·5 mm. longæ, *oblongæ*, apice truncatæ sæpius tridentatæ ; *pedicelli fructiferi filiformes* apice paululum incrassati, flexuosi, *usque ad* 30 *mm. longi*. *Sepala circa* 1 *mm. longa*, ·75 *mm. lata, suborbicularia*, peltata, subacuta, irregulariter *crenato-dentata*, alba. *Corolla* 6–7 *mm. longa, alba* ; *petalo superiore* apice marginibus latiusculis subpatentibus *oblongo, truncato* emarginatove, carinâ crassâ purpurascente, *calcare* gracili *longiusculo* deflexo; *petalo inferiore* apice marginibus latiusculis

patentibus *spathulato, obtusissimo* vel retuso, carinâ viridi prædito, *basi* verisimiliter *subsaccato*; *petalis interioribus* fere rectis apice *modice alatis atropurpureis*. *Fructûs majusculi*, cum rostro 3 mm. longi, 2–2·25 mm. lati, *ovato-elliptici*, superne in rostrum latiusculum compressum angustati *subacuti*, inferne abrupte angustati (haud attenuati), valde compressi et acute carinati, siccitate omnino *tuberculato-rugulosi*.

Hæc species *R. longipedi* plane affinis est, sed per pedicellos fructiferos subduplo breviores cum bracteis truncatis, per sepala minora magis dentata, per corollas angustiores et per fructûs subduplo minores, læviores, inferne haud attenuatos satis differt.

R. prætermissa in fissuris umbrosis rupium ad Mnechounès prope Biskram, in provinciâ Constantinâ Algeriæ, ubi cum *R. longipede* crescit, a cl. Balansa inventa est.

This rare and obscure plant has been described and figured from the single specimen included in Balansa's sheet of *Fumaria longipes* in Herb. Mus. Paris, to which reference has already been made. Its points of distinction from *R. longipes* were apparently overlooked both by Balansa and by Cosson, owing probably to the similarity of its foliage and the inconspicuous nature of its few-flowered clusters of small, pale flowers. It appears to possess, however, a number of minor differences in addition to the widely divergent fruit.

5. Rupicapnos sublævis, sp. nov. (Pl. 15, fig. 2.)

Exsicc. Balansa, Pl. d'Alger. 1853, Mnechounès, near Biskra, in Hb. Mus. Paris (partim), ut *Fumaria longipes*!

Rupicapnos verisimiliter annua, caule suberecto (circa 4 cm. alto) brevissime ramoso prædita. *Folia* pleraque caulina, haud crassa, longe petiolata, cum petiolo subalato 4–6 cm. longa, *ovalia* vel subdeltoidea, foliolis infimis subpetiolatis reliquis sessilibus omnibus paulo confertis, et segmentis secundariis in *lacinias lanceolatas acutas* irregulariter fissis *2-pinnatisecta subquinata*. *Racemi* corymbiformes, *pauci*-(4–8-) *flori*, cum pedunculo (ad 15 mm. longo) *foliis subduplo breviores*. *Bracteæ* 1·5–2 *mm.* longæ, *oblongæ*, acutæ, interdum apice sparsim dentatæ; *pedicelli fructiferi filiformes* apice incrassati, flexuosi, *usque ad* 40 *mm. longi*. Flores haud visi. *Fructûs modici*, cum rostro 3 mm. longi, 1·75–2 mm. lati, *anguste obovati*, superne in rostrum parvulum breviter angustati, *subacuti*, inferne multo attenuati, satis compressi et plane carinati, siccitate *infra rostrum* omnino leviter *tuberculato-rugulosi*.

Hæc species, cujus flores non visi sunt, habitu ad *R. longipedem* accedit sed folia ut in *R. Cossonii* fissa et fructûs rugulosos modicos nec maximos monstrat. *R. prætermissa* pedicellis brevioribus, bracteis truncatis, fructibus magis compressis ovato-ellipticis potius quam obovatis etiam differt.

R. sublævis in fissuris rupium ad Mnechounès prope Biskram in provinciâ Constantinâ Algeriæ, ubi cum *R. longipede* et *R. prætermissâ* crescit, invenitur.

The diagnosis of this rare plant is taken from the solitary example on Balansa's sheet of *Fumaria longipes* in Herb. Mus. Paris, which unfortunately now shows no flowers. Except for the slightly winged petioles, its foliage bears a resemblance to that of *R. Cossonii* rather than *R. longipes*, and its narrow, finely rugose fruit is very distinct.

SECTIO II. SARCOCAPNOIDES.

Plantæ perennes, decumbentes. Racemi multiflori. Flores parvi vel parvuli, 4–10 mm. longi, albi vel roseo-albidi; petalis exterioribus quam interiora fere recta apice modice alata atropurpurea conspicue longioribus et latioribus, in limbos patentes suborbiculares apice dilatatis ut in genere *Sarcocapnos*; stylus fere malleiformis lobis curvatis subpatentibus. Fructûs parvi.

6. RUPICAPNOS SARCOCAPNOIDES, Pomel, Mat. Fl. Atlant. 16 (1860); Nouv. Mat. Fl. Atlant. i. 245 (1874). *Fumaria sarcocapnoides*, Coss. & Dur. in Bull. Soc. Bot. Fr. ii. 306 (1855); *F. numidica* subvar. *sarcocapnoides*, Coss. Comp. Fl. Atlant. ii. 82 (1883–1887). (Pl. **16**.)

Exsicc. Balansa, Pl. d'Alger. 1853, No. 995, in Hb. Mus. Paris (partim), ut *Fumaria corymbosa*!

Rupicapnos perennis sed probabiliter a primo anno florens, caudice brevi crassiusculo ramoso decumbente et caulibus brevissimis prædita. *Folia* pleraque subradicalia, plus minusve glauca, haud crassa, 6–10 cm. longa (petiolo incluso), longe petiolata, *oblongo-deltoidea*, foliolis breviter petiolatis trifido-flabellatis et segmentis secundariis in *lobos oblongo-ellipticos subacutos* irregulariter fissis *quinato-pinnata*. *Racemi* corymbiformes, *circa 20-flori, sæpe furcati*, cum pedunculo gracili *foliis subduplo breviores*. *Bracteæ* circa 1·5 mm. longæ, *late ovales*, cuspidatæ, apice dentatæ; *pedicelli fructiferi capillares* apice paululum incrassati flexuosi, infimi *usque ad 25 mm. longi*. *Sepala circa* 1 *mm. longa*, ·75 *mm. lata, late ovata* vel suborbicularia, peltata, acuta, *dentata,* alba. *Corolla minima*, 4–5 *mm. longa,* carinis crassis viridibus *alba*; *petalis exterioribus quam interiora* multo (saltem 1 mm.) *longioribus et latioribus, superiore* marginibus latissimis patentibus ultra carinæ apicem productis apice *in limbum* magnum *suborbicularem* vel sæpius *obcordatum dilatato, calcare* brevi (1 mm. longo) obovato recto; *inferiore,* ut superius, apice *in limbum* patentem *suborbicularem dilatato, basi haud saccato*; *petalis interioribus* rectis apice plane dilatatis *modice alatis atropurpureis.* Stylus fere malleiformis lobis curvatis subpatentibus. *Fructûs parvi,* sine mucrone circa 2 mm. longi et 1·5 mm. lati, *oblongo-obovati, cum mucrone brevi obtusi*

et inferne multo angustati, satis compressi et plane carinati, siccitate omnino *dense tuberculato-rugulosi.*

Hæc species distinctissima per petala exteriora interioribus longiuscule longiora et latiora affinitatem conspicuam cum genere *Sarcocapnos* monstrat sed fructum monospermum tuberculatum generis *Rupicapnos* habet.

R. sarcocapnoides regionem montanam Algeriæ australis in provinciâ Constantinâ (Djebel Tougour prope Batnam) habitat, ubi in fissuris rupium crescit.

This plant was originally described by Cosson in 1855 from a specimen observed among the exsiccata sent out by Balansa under the number 995 and otherwise referred to *Fumaria numidica*, Cosson noting that the plant constitutes a true passage between the genera *Fumaria* and *Sarcocapnos* owing to the form of its corolla. Later, however, in Illustr. Fl. Atlant. i. 15 (1882), Cosson remarks that *F. sarcocapnoides* appears to be a shade-form only of *F. numidica*, adding that shade-forms of *Sarcocapnos* similarly deviate from the type; and in the Compendium it becomes a sub-variety of *F. numidica.* It is not easy to understand how shade-conditions could transform the corolla-characters of *F. numidica* into those of *F. sarcocapnoides*, developing the margins of the outer petals while rendering depauperate the wings of the inner ones, and as moreover it is not only in their flowers that the two plants differ, the earlier view of Cosson is here followed.

R. sarcocapnoides seems to be a very rare plant, and it is not known to have been collected except by Balansa, from whose specimen at Paris the above diagnosis is taken and the accompanying figure drawn. It was unknown to Pomel, who adopted the species from Cosson.

[7. RUPICAPNOS REBOUDIANA, Pomel, Nouv. Mat. Fl. Atlant. fasc. ii. 379 (1876); n. v. *Fumaria Reboudiana*, Batt. & Trabut, Fl. d'Alger. i. 26 (1888).

Rupicapnos perennis, fragilis, *R. sarcocapnoidi* affinis. *Folia* viridia, foliolis in *segmenta cuneiformia* vel oblonga, *obtusa* fissis *quinato-pinnata. Bracteæ oblongæ*; pedicelli apice incrassati. *Sepala obovata* vel suborbicularia, *valde dentata. Corolla* 9–10 *mm. longa, roseo-albida*; *petalis exterioribus* marginibus latis patentibus *in limbos suborbiculares retusos dilatatis*, superioris *calcare* obovato *longiusculo, inferioris basi valde saccatâ*; *petalis interioribus apice atropurpureis haud conspicue alatis. Fructûs parvi, obovati, breviter mucronati*, in sicco *tuberculato-rugosi.*

R. Reboudiana rupes ad Bou-Taleb (Reboud) Algeriæ australis habitat.

This plant appears distinct from Pomel's brief description, and is retained as a species although no material of it has been seen. It is evidently, as stated by Pomel, a relatively large-flowered ally of *R. sarcocapnoides.*]

Sectio III. TRIPTERYX.

Plantæ perennes decumbentes. Racemi multiflori. Flores parvi vel parvuli, 4–10 mm. longi, albidi, plus minusve luteo-tincti: petalis exterioribus quam interiora fere recta apice ut interdum exteriora superant conspicue alata, haud atropurpurea (nisi interne vel brevissime ad apicem ipsum) vix longioribus, marginibus eorum apice patentibus sæpe in limbos suborbiculares dilatatis; stylus furcæformis lobis adscendentibus. Fructûs parvi ad majusculi.

8. Rupicapnos numidica, Pomel, Mat. Fl. Atlant. 16 (1860), ex parte; Nouv. Mat. Fl. Atlant. i. 243 (1874). *Fumaria numidica*, Coss. & Dur. in Bull. Soc. Bot. Fr. ii. 306 (1855), ex parte; Coss. Illustr. Fl. Atlant. i. 15 (1882), ex parte; Comp. Fl. Atlant. ii. 81 (1883–1887), ex parte; Batt. & Trabut, Fl. d'Alger. i. 25 (1888), ex parte. (Pl. **9**, fig. 6.)

Exsicc. Cosson, Constantine, 1853, in Hb. Mus. Paris, ut *F. numidica*! Choulette, Fragm. Fl. Alger. Constantine, 1855, in Hb. Kew, ut *F. numidica*! Soc. Dauph. No. 285, Constantine, 1874, Dr. Reboud!

Rupicapnos perennis sed interdum a primo anno florens, caudice brevi crassiusculo ramoso decumbente tandem vestigiis petiolorum emarcidorum donato et caulibus brevissimis prædita. *Folia* pleraque subradicalia, crassiuscula, glaucescentia, 6–15 (raro ad 25) cm. longa (petiolo incluso), longe petiolata, *subdeltoidea*, foliolis 2–3-paribus haud confertis breviter petiolatis et segmentis secundariis in *lacinias* satis remotas *oblongas* vel cuneatas *obtusas* sæpe leviter mucronatas irregulariter fissis *2–3-pinnatisecta*. *Racemi* corymbiformes, densi, *multi*-(20–30-) *flori*, breviusculi, cum pedunculo (ad 4 cm. longo) *foliis saltem subduplo breviores*. *Bracteæ* 1–1·5 mm. longæ, *lanceolatæ*, acuminatæ, obscure denticulatæ; *pedicelli fructiferi fere capillares* apice incrassati flexuosi *infimi usque ad 25 mm. longi*. *Sepala circa* 1·5 *mm. longa*, ·75 *mm. lata*, *oblongo-lanceolata*, peltata, acuta, basin versus *parce dentata*, albida. *Corolla minima*, *circa* 4 *mm.* (4–5 mm. ap. Pomel) *longa*, carinis viridibus vel lutescentibus *albida*; *petalo superiore* apice marginibus latiusculis subpatentibus *oblongo* vel anguste obovato, *obtusissimo* vel truncato, *calcare* minimo *brevissimo* (vix 1 mm. longo) recto; *petalo inferiore* apice marginibus latis patentibus sensim dilatato *cuneato-obovato obtusissimo*, *basi haud saccato*; *petalis interioribus* fere rectis apice *alâ latâ* lutescente rotundatâ inter petalorum exteriorum margines quos paululum superat subpatulâ præditis *obscure atropurpureis*. *Fructûs modici*, sine mucrone 2·75 mm. longi, 2 mm. lati, *oblongo-obovati* (obovati ap. Pomel), *cum mucrone brevi obtusissimi* et inferne attenuati, satis compressi et plane carinati, siccitate omnino *dense tuberculato-rugosi*.

R. numidica quæ per flores minimos apice dilatatos brevissime calcaratos

facile distinguenda est, in Algeriâ rupes calciferas prope urbem Constantinam et forsan alios locos habitat.

Pomel is here followed in restricting the *Fumaria numidica* of Cosson, which includes several distinct plants collected in different Algerian stations, to the form growing in the neighbourhood of Constantine, the first locality cited by Cosson in his original diagnosis of *F. numidica*.

There is a flowerless specimen of this plant in Herb. Kew, collected by Bové at Constantine in September, 1839, in which the leaves are more than 25 cm. in length.

9. Rupicapnos Cossonii, sp. nov.

Fumaria numidica, Coss. & Dur. in Bull. Soc. Bot. Fr. ii. 306 (1855), ex parte; Coss. Illustr. Fl. Atlant. i. 15 (1882), ex parte; Comp. Fl. Atlant. ii. 81 (1883–1887), ex parte; Batt. & Trabut, Fl. d'Alger. i. 25 (1888), ex parte.

Icon Cosson, Illustr. Fl. Atlant. i. tab. 9, figs. 1–11, ut *F. numidica*.

Exsicc. Balansa, Pl. d'Alger. 1853, No. 995, in Hb. Mus. Paris (partim), Hb. Kew, Hb. Mus. Brit. et Hb. Manchester, ut *F. corymbosa*!

Rupicapnos perennis, caudice brevi crasso ramoso decumbente tandem vestigiis petiolorum emarcidorum donato atque caulibus brevissimis vel fere nullis prædita. *Folia* pleraque radicalia, crassa, plus minusve glauca, cum petiolo 5–10 cm. longa, longe petiolata, *oblonga vel ovalia*, foliolis (2–3-paribus) satis confertis, breviter petiolatis vel supremis subsessilibus, et segmentis secundariis in *lacinias* subdivaricatas *oblongas obtusas* obscure mucronatas *vel acutiusculas* irregulariter fissis *2–3-pinnatisecta*. *Racemi* subcorymbiformes, *multi*-(15–30-) *flori*, pedunculis paulo breviores, cum pedunculo (ad 5 cm. longo) *folia subæquantes* vel in formis umbrosis breviores. *Bracteæ* 1–1·5 mm. longæ, *lanceolatæ*, acutæ vel acuminatæ, parce serrulatæ; *pedicelli fructiferi graciles* (fere filiformes), *anguste clavati*, apice incrassati, flexuosi, *infimi usque ad 25 mm. longi*. *Sepala* 1–1·5 *mm. longa*, ·5–1 *mm. lata*, *ovalia vel ovata*, peltata, subacuta, plus minusve *crenato-dentata*, nervo dorsali viridiusculo albida. *Corolla parva*, 4–5 *mm. longa*, haud gracilis, præter carinas virescentes *albida*; *petalo superiore* apice marginibus latiusculis patentibus *anguste obovato obtusissimo* vel etiam retuso, *calcare satis longo* adscendente paululum curvato; *petalo inferiore* lato marginibus latis patentibus apice sensim dilatato *cuneato-obovato obtusissimo* (apice quam petalum superius paulo latiore), *basi haud saccato*; *petalis interioribus* fere rectis apice vix coalitis *alâ latâ* lutescente præsertim ad apicem dilatatâ inter petalorum exteriorum margines quos paulo superat subpatulâ præditis verisimiliter interne et *apice ipso brevissime purpureo-tinctis*. Stylus furcæformis. *Fructûs modici*, sine mucrone 2–2·5 mm. longi, 1·75–2 mm. lati, *subrotundo-obovati* vel obovati, *cum mucrone distincto obtusi*, plane compressi et valde carinati, siccitate omnino dense *tuberculato-rugosi* submuricati.

Hæc species *R. numidicæ* affinis est sed foliolis laciniisque minus remotis, racemis relative longioribus, pedicellis crassioribus, corollis majoribus longius calcaratis, fructibus cum mucrone longiore latioribus differt.

R. Cossonii fissuras rupium ad Djebel-Tougour, prope Batnam, in provinciâ Constantinâ Algeriæ habitat.

Cosson's original *Fumaria numidica* is partly founded on this plant and the plate in his 'Illustrationes Floræ Atlanticæ' is evidently drawn from it. As Pomel, however, has adopted this specific epithet for the form found at Constantine, and Balansa's plant from Batna appears to be an essentially distinct species with several points of difference, a new name becomes necessary, and it therefore seems fit to commemorate Cosson, who was the first to distinguish and describe the small-flowered species of the genus.

10. Rupicapnos tenuifolia, Pomel, Nouv. Mat. Fl. Atlant. i. 244 (1874).
Fumaria tenuifolia, Batt. & Trabut, Fl. d'Alger. i. 26 (1888); *F. numidica*, Coss. Comp. Fl. Atlant. ii. 81 (1883–1887), ex parte.

Exsicc. Bourgeau, Pl. d'Alger. 1856, No. 243, ut *F. numidica*!

Rupicapnos perennis caudice brevi crassiusculo ramoso decumbente et caulibus brevissimis ut in *R. Cossonii*. *Folia* pleraque radicalia, vix crassiuscula, plus minusve glauca, cum petiolo longo gracilescente 5–20 cm. longa, *anguste oblonga*, foliolis sæpius 3-paribus breviter petiolatis et segmentis secundariis (interdum subflabellatis) in *lacinias* confertas *lineari-oblongas*, vel oblongas in foliis primariis, *acutas* vel obtusiusculas (parvas obovatas obtusas ap. Pomel) irregulariter fissis *2–3-pinnatisecta*. *Racemi* corymbiformes, densiusculi, *multi*-(20–40-) *flori* (pauciflori ap. Pomel), cum pedunculo gracili (ad 5 cm. longo) *foliis subduplo breviores* nisi in formis nanis. *Bracteæ* 1–1·5 mm. longæ, *oblongæ*, acuminatæ; *pedicelli fructiferi capillares* apice incrassati flexuosi infimi *ad 20 mm. longi*. *Sepala circa* 1·5 *mm. longa*, ·5–·75 *mm. lata, lanceolata* (ovata ap. Pomel), vix peltata, acuta, *parce denticulata*, albida. *Corolla minima*, 4–4·5 *mm. longa*, præter carinas lutescentes vel virescentes *albida*; *petalo superiore* apice marginibus latis patentibus *in limbum suborbicularem obtusissimum dilatato, calcare breviusculo* satis gracili fere recto sed apice dilatato, [nectario paulo arcuato calcar medium attingente ap. Pomel]; *petalo inferiore* apice marginibus latis *in limbum suborbicularem obtusissimum* vel truncatum abrupte *dilatato, basi haud saccato*; *petalis interioribus* fere rectis apice *alâ latâ* lutescente rotundatâ patulâ petalorum exteriorum margines subæquante præditis *haud atropurpureis*. *Fructûs parvi*, sine mucrone 1·75–2 mm. longi, 1·5–1·75 mm. lati, *subrotundi* vel subrotundo-obovati (obovati ap. Pomel), *cum mucrone gracili obtusissimi*, paululum compressi et obscure carinati, siccitate omnino *dense tuberculato-rugosi*.

Hæc species duabus præcedentibus (*R. numidicæ* et *R. Cossonii*) affinis est, sed per folia graciliora magis dissecta, per petala exteriora in limbos

suborbiculares dilatata et per fructûs minores gracile mucronatos separanda est.

R. tenuifolia regionem montanam Algeriæ australis in provinciâ Oranensi ad Itimam (Pomel), prope Stitten et forsan ad alios locos habitat.

The diagnosis of *R. tenuifolia* has been taken from Bourgeau's exsiccata at Kew and in Herb. Manchester, which, while differing in some particulars from Pomel's original description, as indicated, seem to be essentially conspecific although perhaps varietally separable. The relationship of the two forms is indeterminable in the absence of authentic material of the Itima plant seen by Pomel, which appears to differ chiefly by its broader leaf-segments, fewer-flowered racemes, broader sepals, and less rotund fruits.

11. RUPICAPNOS CAPUT-PLATALEÆ, Pomel, Nouv. Mat. Fl. Atlant. i. 244 (1874). *Fumaria caput-plataleæ*, Batt. & Trabut, Fl. d'Alger. i. 25 (1888). (Pl. **9**, fig. 7.)

Exsicc. Murbeck, Iter Alger.-Tunetanum, 1896, Dyr-el-Kef, Tunetia media, in Hb. Mus. Brit., ut *F. numidica* var. *longipes* !

Rupicapnos perennis, glauca, caudice crassiusculo et caulibus abbreviatis ut in *R. numidicâ*. *Folia* pleraque subradicalia, crassa, cum petiolo longissimo 10–15 cm. longa, *subdeltoidea*, foliolis flabellatis infimis petiolatis reliquis sæpius fere subsessilibus in *segmenta* remota *cuneiformia* vel obovata *obtusissima* rarius obscure mucronata fissis *irregulariter 2-pinnatisecta subquinata*. *Racemi* primo corymbiformes cito elongati, densi, *conspicue multi-(30–50-)flori*, cum pedunculo ad 8 cm. longo *folia paulo superantes* vel parum breviores. *Bracteæ* 1–1·5 mm. longæ, *lineari-lanceolatæ*, acuminatæ, subintegræ ; *pedicelli fructiferi filiformes* apice incrassati longissimi (infimi *usque ad* 50 *mm. longi*). *Sepala circa* 2 *mm. longa*, 1–1·5 *mm. lata*, *ovata*, peltata, acuminata, *integriuscula* vel basi parce dentata, albida. *Corolla parva*, 4–5 *mm. longa*, præter carinas virescentes *albida* ; *petalo superiore* apice marginibus latis patentibus *late obovato* vel suborbiculari *truncato* vel obtusissimo, *calcare breviusculo* fere recto, [nectario brevissimo calcar vix ineunte ap. Pomel] ; *petalo inferiore* apice marginibus latissimis patentibus *in limbum suborbicularem truncatum dilatato*, *basi haud saccato* ; *petalis interioribus* fere rectis apice *alâ latissimâ* lutescente rotundatâ in spatulæ formâ inter petalorum exteriorum margines quos longe superat patente præditis *interne obscure atropurpureis*. *Fructûs mediocres*, sine mucrone circa 2·25 mm. longi et 2 mm. lati, *fere elliptici*, *cum mucrone obtusiusculi*, satis compressi sed parum carinati, siccitate omnino *dense tuberculato-rugosi*.

R. caput-plataleæ valde *R. numidicæ* affinis, sed per alarum latitudinem in petalis interioribus quæ petalorum exteriorum margines longe superant mirabilis est. Foliorum segmentis cuneiformibus obtusioribus, racemis

conspicue multifloris cum pedicellis fructiferis ad 50 mm. longis et fructibus ellipticis ab hujus sectionis speciebus aliis insuper differt.

Hæc species ad El Ghicha in regione montanâ Djebel Amour Algeriæ australis (Pomel) primum inventa est atque prope Dyr-el-Kef Tunetiæ mediæ et forsan in aliis locis crescit.

This remarkable plant has been described from Murbeck's exsiccata in Herb. Mus. Brit., collated with the diagnosis of Pomel, with which it substantially agrees. The fanciful name "*caput-plataleæ*" or "spoonbill's head" is perhaps not inapt owing to the great apical dilation of the inner petals.

Murbeck's reference of his exsiccata to *Fumaria numidica* var. *longipes*, Cosson, is probably due to the great length of the fruiting pedicels, which characterizes this plant in common with *R. longipes*. In every other respect, however, *R. caput-plataleæ* is widely different from the annual species distinguished by Cosson.

12. Rupicapnos erosa, Pomel, Nouv. Mat. Fl. Atlant. i. 243 (1874). *Fumaria erosa*, Batt. & Trabut, Fl. d'Alger. i. 26 (1888); *F. numidica*, Coss. & Dur. in Bull. Soc. Bot. Fr. ii. 306 (1855), ex parte; Coss. Illustr. Fl. Atlant. i. 15 (1882), ex parte; Comp. Fl. Atlant. ii. 81 (1883–1887), ex parte.

Exsicc. Kralik, Pl. Alger. 1858, No 3, ut *F. numidica*! Paris, Iter Bor.-Afric. 1886, No. 10, ut *F. numidica*! Chevallier, Pl. Saharæ Alger. 1897, No. 147, ut *F. numidica*!

Rupicapnos perennis *R. numidicæ* habitu sed caulibus nonnunquam crassioribus. *Folia* pleraque subradicalia, crassiuscula, glaucescentia, cum petiolo longo 3–15 cm. longa, *oblonga*, foliolis (vulgo 3-paribus) sæpius brevissime petiolatis et segmentis secundariis in *lobos obovatos* vel rotundatos *obtusissimos* (vix mucronatos) divaricatos sæpe incisos aut rarius oblongos subacutos fissis (pinnulis subflabellatis et earum lobis sæpe alternantibus) *irregulariter 2–3-pinnatisecta*. *Racemi* corymbiformes, *10–20-flori*, cum pedunculo 2–5 cm. longo *foliis multo breviores* vel in formis apricis nanis folia subæquantes. *Bracteæ* 1–1·5 mm. longæ, *lineari-lanceolatæ*, acuminatæ; *pedicelli fructiferi filiformes* apice abrupte incrassati flexuosi infimi *usque ad* 25 *mm. longi*. *Sepala* 1·5–2·5 *mm. longa*, 1–1·5 *mm. lata*, *ovata* vel oblonga, peltata, acuminata, plus minusve *dentata*, albida. *Corolla* 6–10 *mm. longa*, quam in hujus sectionis aliis speciebus relative angustior, præter carinas crassas apicem haud attingentes lutescentes vel pallide virescentes *alba*; *petalo superiore* apice marginibus latiusculis patentibus *oblongo-obcordato retuso*, *calcare longiusculo* deflexo ad basin angustato; *petalo inferiore* marginibus latis patentibus *in limbum suborbicularem retusum* abrupte *dilatato*, *basi* obscure *subsaccato*; *petalis interioribus* fere rectis apice *alâ latâ* lutescente præsertim ad apicem dilatatâ angulatâ subpatulâ petalorum exteriorum

margines subæquante præditis verisimiliter *interne* nec externe *purpureo-tinctis*. *Fructûs parvuli*, sine mucrone 2–2·25 mm. longi et circa 2 mm. lati, *subrotundo-obovati* vel subrotundi, *cum mucrone breviusculo* quandrangulato *obtusissimi* et inferne in stipitem obscurum angustati, paulo compressi et plane carinati, siccitate omnino *dense tuberculato-rugosi*.

β. major, var. nov.

Exsicc. Clary, no. 33, Ghada de Ghernenta, 1888, in Hb. Mus. Paris. ut *Fumaria numidica* (*Rupicapnos erosa*, Pomel)!

Planta multo major habitu laxiore. Folia haud crassa, viridia, cum petiolo longo gracili 20–30 cm. longa, subquinata. *Racemi* densi, *multi*-(15–30-) *flori*, cum pedunculo (ad 8 cm. longo) *folia subduplo breviores*. *Bracteæ* minimæ, circa 1 mm. longæ, *ovato-lanceolatæ*, acuminatæ, obscure denticulatæ; *pedicelli fructiferi capillares*, apice incrassati, infimi *ad* 40 *mm. longi*. *Sepala parva*, 1–1·5 *mm. longa*, ·75–1 *mm. lata*, acuta. Corolla 8–10 mm. longa. *Fructûs majusculi*, sine mucrone circa 2·5 mm. longi et 2·75 mm. lati, *subrotundi*, siccitate *grosse et dense tuberculato-rugosi*. Aliter ut in typo.

Hæc planta ab hujus sectionis aliis speciebus per foliorum 2–3-pinnatisectorum lobos latos divaricatos, per corollas angustiores pallidiores multo majores calcare longiore petaloque inferiore subsaccato præditas, et per fructûs subrotundos breviter mucronatos distinguenda est.

R. erosa regionem montanam Djebel Amour Algeriæ australis prope El Beida (ap. Pomel) et ad Laghouat habitat; varietas *major* hactenus ad Ghada de Ghernenta solum inventa est.

The oldest specimens of this plant, collected at Laghouat by Kralik, and also others in Herb. Kew received from Reboud, are late gathered and more or less exhausted individuals bearing small flowers, but are none the less clearly conspecific with the much finer examples obtained more recently in the same district by Paris and Chevallier. It is noteworthy that the foliage of the weaker plants shows relatively narrow and acute segments.

The variety *major* is a much larger plant, with finer flowers, almost recalling the section *Callianthos*. It appears, however, to possess all the essential features of the Laghouat form, except that its bracts and sepals are smaller and broader.

Sectio IV. CALLIANTHOS.

Plantæ perennes decumbentes eis sectionum aliarum vulgo majores. Racemi multiflori. Flores magni, 12–16·5 mm. longi, albidi vel pallide purpurei; petalis exterioribus quam interiora apice sursum curvata modice alata atropurpurea vix longioribus, marginibus eorum apice deflexis patentibus vel sursum recurvatis in limbos suborbiculares nunquam dilatatis; stylus malleiformis lobis divaricatis. Fructûs modici ad maximi.

Subsectio **AFRICANÆ**.

Foliorum lobi relative angusti. Flores albidi.

13. Rupicapnos africana, sp. nov. (non *R. africana*, Pomel).

Fumaria africana, Lamarck, Encycl. ii. 569 (1788); Coss. & Dur. in Bull. Soc. Bot. Fr. ii. 305 (1855), ex parte; Coss. Comp. Fl. Atlant. ii. 80 (1883–1887), ex parte; *F. corymbosa*, Desfontaines in Act. Soc. Hist. Nat. Paris, i. 26 (1792), et Fl. Atlant. ii. 124 (1800), non *F. corymbosa*, Hammar; *Rupicapnos graciliflora*, Pomel, Nouv. Mat. Fl. Atlant. i. 241 (1874); *Fumaria graciliflora*, Batt. & Trabut, Fl. d'Alger. i. 25 (1888).

Icon. Desfontaines, *l.c.* i. tab. 6, ut *F. corymbosa*.

Exsicc. Bourgeau, Pl. d'Alger. 1856, No. 181, Nedroma, in Hb. Mus. Paris (fructibus plerisque exclusis) et in herb. aliis (partim), ut *F. africana*!

Rupicapnos perennis, caudice crassiusculo ramoso decumbente sæpe paulo elongato tandem vestigiis petiolorum emarcidorum donato caulibusque semper brevibus. *Folia* pleraque subradicalia, plus minusve glaucescentia, 10–25 cm. longa (petiolo gracilescente incluso), longe petiolata, *oblongo-deltoidea*, foliolis ambitu fere ovatis vulgo breviter petiolatis et segmentis secundariis subflabellatis in *lacinias oblongas* vel lineari-oblongas *acutas* rarius obtusas mucronatas irregulariter fissis *2-pinnatisecta subquinata. Racemi* corymbiformes, *15–20-flori*, cum pedunculo (ad 6 cm. longo) *foliis subduplo breviores. Bracteæ* 1·5–2·5 mm. longæ, *lanceolatæ*, tenuiter acuminatæ (denticulatæ ap. Pomel); *pedicelli fructiferi filiformes* apice incrassati, *infimi ad 50 mm. longi. Sepala circa 3 mm. longa, 2 mm. lata, ovalia* vel ovato-lanceolata, peltata, acuminata, *leviter dentata* vel ad basin dentibus angustissimis sublaciniata (subintegra ap. Pomel). præter nervum dorsalem latum viridiusculum albida. *Corolla maxima*, 14–16 *mm. longa, gracilis*, carinis viridibus *albida*; *petalo superiore* apice marginibus parum dilatatis subpatentibus vel deflexis nonnunquam leviter purpureo-tinctis *anguste oblongo obtusissimo, calcare longo* (circa 5 mm.) deflexo basi angustato apice rotundato, [nectario longissimo haud incurvato ap. Pomel]; *petalo inferiore* marginibus patentibus apice vix dilatatis *lineari-oblongo, obtusiusculo,* ad basin ipsam *inconspicue* (valde ap. Pomel) *gibboso-saccato*; *petalis interioribus* apice sursum curvatis *modice alatis atropurpureis.* Stylus malleiformis. *Fructûs modici,* sine mucrone circa 2·5 mm. longi, 2 mm. lati, *obovato-elliptici* (elongato-elliptici ap. Pomel), *cum mucrone brevissimo obtusissimi* vel obtusi, inferne in stipitem angustum obscurum breviter angustati, paulo compressi et acute carinati, siccitate omnino *tenuiter tuberculato-rugosi.*

Hæc species prope Mascaram (Desfontaines) et in rupibus dolomiticis ad Nador prope Tiaret (Pomel) in parte orientali atque prope Tlemcen (Desfontaines) et ad Nedromam in parte occidentali provinciæ Oranensis

in Algeriâ crescit; etiam in locis aliis hujus provinciæ sine dubio videnda est.

This plant was discovered by Desfontaines prior to 1788 near Tlemcen and Mascara, and specimens of it were brought to France for cultivation. Its earliest description appears in Lamarck's Encyclopedia under the name of *Fumaria africana,* and four years later it was re-described by its discoverer as *F. corymbosa.* Both of the descriptions are in some detail and in virtual agreement, and with these and Desfontaines' very fair figure, the diagnostic characters of the species can be determined with some accuracy. The plant is evidently one with rather finely cut leaf-segments, ovate sepals, slender whitish corolla with a long spur, and slightly pointed fruits. It is not known whether any original specimen of Lamarck's or Desfontaines' is now in existence.

In 1855 Cosson, in establishing the section *Petrocapnos* of *Fumaria*, again briefly describes this species, but extends its definition to include the purple-flowered plant occurring about Oran; and Hammar, in his Monograph of *Fumaria*, bases his description on the Oran form.

In Pomel's revision of his genus *Rupicapnos* (Nouv. Mat. Fl. Atlant. i. p. 240) six species of this group are established, and the name *R. africana*, with which *Fumaria africana* Lamarck is identified, is restricted to a purple-flowered form, characterized by very broad leaf-segments, large, orbicular sepals, and a very short spur to the upper petal. This plant is said to grow at Garrouban, Tlemcen, Gorges de la Tafna, Nedroma, and Oran, Tlemcen being one of Desfontaines' stations. Only one undoubted example of Pomel's plant, however, obtained in the first-named of these localities, has come under observation, the exsiccata examined from Tlemcen, Nedroma, and Oran being clearly different.

It is not easy to see what led Pomel to apply the epithet *africana* to this apparently uncommon purple-flowered form rather than to Desfontaines' white-flowered plant, but it is likely that when Pomel's account of these plants was written, he had not been able to consult the works of Lamarck and Desfontaines, a reference to which would have shown the distinctness of the original *F. africana* from the form to which he restricted this specific name.

As Article 48 of the current Rules of Nomenclature requires that original specific epithets must be retained (or restored) for the species to which they were first given, it becomes necessary reluctantly to differ from Pomel and to regard his *Rupicapnos africana* as a stillborn name, transferring it to the plant originally described by Lamarck. This appears to be conspecific with Pomel's *R. graciliflora.*

The above diagnosis of this species is based on Bourgeau's sheet of *F. africana* from Nedroma (No. 181) in Herb. Mus. Paris (excluding the detached fruits, which are a mixture), together with the small examples on the sheets of the same set in Herb. Manchester, Herb. Kew, and Herb.

Mus. Brit. These have been collated with the original accounts of *Fumaria africana*, *F. corymbosa*, and *Rupicapnos graciliflora* by Lamarck, Desfontaines, and Pomel respectively.

The admixture of this species and of the purple-flowered Oran form on Bourgeau's sheets of *F. africana* may be taken as evidence that these two plants grow in company at Nedroma, as has already been seen sometimes to happen in the case of some of the small-flowered species.

14. RUPICAPNOS DECIPIENS, sp. nov.

Fumaria corymbosa, Boissier, Voy. Bot. Esp. ii. 19 (1839–1845), non Desfontaines; *F. africana*, Willkomm & Lange, Fl. Hisp. iii. 878 (1880), non Lamarck; Coss. Comp. Fl. Atlant. ii. 80 (1883–1887), ex parte.

Exsicc. Huter, Porta & Rigo, Iter Hisp. 1879, No. 516, ut *F. africana*! Reverchon, Pl. d'Andalousie, 1890, Grazalema, ut *F. africana*! Porta & Rigo, Iter IV Hisp. 1895, No. 23, ut *F. africana*!

Rupicapnos perennis, glauca, radice longissimo, caudice crassiusculo ramoso decumbente et caulibus semper brevibus ut in *R. africanâ*. *Folia* pleraque subradicalia, glaucescentia, plus minusve carnosa, 10–25 cm. longa (petiolo incluso), longissime petiolata, *deltoidea*, foliolis subdeltoideis (duobus infimis multo majoribus petiolatis reliquis sæpissime subsessilibus) et segmentis secundariis subflabellatis in *lobos oblongos ellipticos vel cuneatos acutos vel obtusos* vix mucronatos irregulariter fissis *2-pinnatisecta subquinata*. *Racemi* corymbiformes, *10–25-flori*, cum pedunculo (ad 5 cm. longo sæpius multo breviore) *foliis subduplo breviores*. *Bracteæ* 2–3 mm. longæ, albido-virescentes, *oblongæ*, acutæ vel acuminatæ, interdum sparsim serrulatæ; *pedicelli fructiferi graciles*, apice abrupte incrassati, flexuosi, longissimi (*infimi ad* 65 *mm. longi*). *Sepala* 2·5–4 *mm. longa*, 2–3 *mm. lata, late ovata* rarius suborbicularia, peltata vel cordata, acuta, basin versus leviter *crenato-dentata*, nervo dorsali lato viridiusculo albida. *Corolla maxima*, 12–16 *mm. longa*, carinis viridiusculis *albida*; *petalo superiore* marginibus apice plane dilatatis subpatentibus sæpe pallide purpurascentibus *fere oblongo* vel oblongo-obovato, *obtusissimo* vel etiam retuso, carinâ apicem versus attenuatâ, *calcare modico* (circa 4 mm. longo) vix curvato apice rotundato; *petalo inferiore* marginibus patentibus apice valde dilatatis *spathulato obtusissimo*, ad basin ipsam sæpius *gibboso-saccato*; *petalis interioribus* sursum curvatis apice *modice alatis atropurpureis*. *Fructûs maximi*, sine mucrone 3–3·25 mm. longi, circa 3 mm. lati, *subrotundo-obovati* vel subrotundi, *cum mucrone brevi* quadrangulato *obtusi* vel obtusissimi et inferne parum angustati, paulo compressi et valde carinati, siccitate omnino *dense* et elevato *tuberculato-rugosi*.

β. mauritanica, var. nov.

Exsicc. J. Ball, Tetuan, 1851, in Hb. Kew, ut *Fumaria corymbosa*! Hooker, Tetuan, 1871, in Hb. Kew, ut *F. africana*!

Margines petalorum exteriorum quam in typo paulo latiores. *Fructûs* sine *mucrone brevissimo* 3–3·25 mm. longi, 2–2·5 mm. lati, *oblongo-oborati*, eis typi multo angustiores. Aliter ut typus.

Hæc rara planta certe *R. africanæ* valde affinis est, sed foliis brevioribus deltoideis lobis latioribus præditis, bracteis sepalisque latioribus, corollâ minus gracili, petalorum exteriorum marginibus apice latioribus, calcare breviore, fructibus majoribus valdius tuberculatis separanda est atque specifice differre videtur.

R. decipiens in fissuris rupium, ad 400 m. adscendens, regionis Sierra de Alora et Pizarra in provinciâ Malacitanâ atque prope Grazalemam in provinciâ Gaditanâ Hispaniæ invenitur; varietas *mauritanica* prope Tetuan in Mauritaniâ et forsan ad Aloram cum typo crescit.

The specimens of this plant collected originally by Boissier at Alhaurin (= Alora ?), now in the herbaria at Kew and the British Museum, are shade-forms with relatively broad leaf-segments and poorly developed flowers. Their fruits are found—rather unexpectedly—to differ from those of the exsiccata collected at Alora by Huter, Porta & Rigo (No. 516), and rather to resemble those of the Tetuan form.

[15. Rupicapnos platycentra, Pomel, Nouv. Mat. Fl. Atlant. i. 242 (1874); n. v. *Fumaria platycentra*, Batt. & Trabut, Fl. d'Alger. i. 25 (1888).

Foliorum segmenta in *lobos parvos oboratos* vel lanceolatos profunde fissa. *Bracteæ oblongæ*, denticulatæ; pedicelli apice incrassati. *Sepala orbicularia, valde dentata*, corollæ tubum æquantia. *Corolla* 14 *mm. longa, albida*; petali superioris margines apice paulo dilatati, *calcar circa* 4 *mm. longum* vix curvatum apice abrupte rotundatum, nectarium flexuosum, incurvatum; *petala interiora apice purpurea. Fructûs* cum mucrone quadrangulato *ovali-elliptici*, siccitate *tuberculato-rugosi.*

Hæc species rupes ad Kef Iroad prope Toucriam in Algeriâ habitat.

This plant is maintained as a separate species in deference to the views of Pomel, although no material of it has been available for examination. It appears to be closely allied to *R. decipiens*, differing chiefly in its more finely divided foliage and its strongly toothed, orbicular sepals.]

16. Rupicapnos cerefolia, Pomel, Nouv. Mat. Fl. Atlant. i. 242 (1874). *Fumaria cerefolia*, Batt. & Trabut, Fl. d'Alger. i. 25 (1888); *F. africana*, Coss. Comp. Fl. Atlant. ii. 80 (1883–1887), ex parte, non Lamarck.

Exsicc. Cosson, Djebel Zaccar, près Milianah, 1854, in Hb. Kew, ut *Fumaria corymbosa* ! Joad, Milianah, 1873, in Hb. Kew, ut *F. africana* ! Cosson, Milianah, 1875, in Hb. Kew, ut *F. africana* ! Soc. Dauphinoise, No. 672, Milianah, ut *F. africana* !

Rupicapnos perennis, plus minusve glauca, caudice crassiusculo caulibusque

brevibus ut in *R. africanâ*. *Folia* pleraque subradicalia, glaucescentia, 10–20 cm. longa (petiolo gracili incluso), longe petiolata, *oblonga*, foliolis 3-paribus subdeltoideis brevissime petiolatis et segmentis secundariis in *lacinias* satis remotas, *parvas*, *lineari-oblongas*, *acutas* mucronatasve profunde incisis *2–3-pinnatisecta*. *Racemi* racemoso-corymbiformes, *20–25 flori*, cum pedunculo (ad 7 cm. longo) *foliis* sæpissime *paulo* rarius subduplo *breviores*. *Bracteæ* 1·5–4 mm. longæ, *oblongæ* (lineares ap. Pomel), acuminatæ; *pedicelli fructiferi filiformes* apice vix incrassati longissimi (*infimi ad* 60 *mm. longi*). *Sepala* 3 *mm. longa*, 1·5–1·75 *mm. lata*, *ovata vel lanceolato-ovata*, peltata, acuta vel acuminata, plus minusve irregulariter *dentata* vel basi laciniata, præter nervum dorsalem angustum viridiusculum albida. *Corolla maxima*, sæpe gracilis, 14–16·5 *mm. longa* (12 mm. ap. Pomel), carinis gracilibus viridiusculis *albida* vel roseo-albida; *petalo superiore* marginibus apice paulo dilatatis sursum recurvatis vel patentibus *anguste oblongo obtusissimo*, *calcare longo* (circa 5 mm.) deflexo ad basin angusto sed apicem versus rotundato; *petalo inferiore* marginibus latis patentibus apice satis dilatatis *subspathulato obtuso*, nonnunquam ad basin ipsam *obscure saccato*; *petalis interioribus* sursum curvatis apice *modice alatis* subtruncatis *breviter* sed læte *atropurpureis*. *Fructûs modici*, sine mucrone circa 2·5 mm. longi et 2 mm. lati, *obovato-elliptici*, cum mucrone longo *acuminati*, valde compressi et plane carinati, siccitate omnino *grosse tuberculato-rugosi*.

Hæc pulchra et distinctissima species per foliorum magis decompositorum lacinias parvas angustas, per corollas maximas roseo-albidas apice breviter sed conspicue atropurpureo-maculatas et per fructûs modicos subellipticos acuminatos inter hujus sectionis alias species notabilis et facile distinguenda est.

R. cerefolia prope Milianah atque Mazis (ap. Pomel) in provinciâ Algeriensi Algeriæ invenitur.

The above description, which has been drawn up from the exsiccata cited, agrees with Pomel's diagnosis except that in the material examined the bracts and sepals seem rather broader, and the corolla is larger, the flowers being especially fine in Soc. Dauph. No. 672, and the specimen at Kew collected by Joad. Pomel's diagnosis seems to have been taken from poorly grown plants, and is corrected by Battandier & Trabut (*l. c.*), who observe that the flowers of *F. cerefolia* are very large, not less than 15 mm. in length.

The flower and dissections of *Fumaria africana* in Cosson's Illustr. Fl. Atlant. i. tab. 9, figs. 12–20, appear to have been drawn from a plant of this species.

17. Rupicapnos speciosa, Pomel, Nouv. Mat. Fl. Atlant. i. 241 (1874). *Fumaria speciosa*, Batt. & Trabut, Fl. d Alger. i. 25 (1888); *F. africana*, Coss. Comp. Fl. Atlant. ii. 80 (1883–1887), ex parte, non Lamarck.

Exsicc. Warion, Saida, 1872, in Hb. Kew (sine fructibus), ut *F. africana*!

Rupicapnos perennis habitu *R. africanæ*. *Folia* fere ut in *R. africanâ* (maxima ap. Batt. & Trab.) sed *oblonga*, segmentis secundariis subflabellatis in *lacinias* latiuscule *oblongas, subacutas* vel mucronatas fissis *2-pinnatisecta*. Racemi *F. africanæ*. *Bracteæ* 2–4 mm. longæ, *lanceolatæ*, acuminatæ; *pedicelli fructiferi filiformes* apice incrassati. *Sepala circa* 3 *mm. longa ac lata*, fere *orbicularia* (corollæ tubum subæquantia), peltata, acuta vel breviter acuminata, *valde dentata*, albida. *Corolla magna*, 14–15 *mm. longa*, carinis viridibus *albida*; *petalo superiore* marginibus apice vix dilatatis dilute purpurascentibus *oblongo obtuso, calcare brevi* (circa 3 mm. longo) apice rotundato, [nectario lineari incurvato ap. Pomel]; *petalo inferiore* marginibus patentibus apice paulo dilatatis *lineari-oblongo obtuso*, basi *gibboso-saccato*; *petalis interioribus apice violaceo-atropurpureis*. *Fructûs* verisimiliter *modici, cum mucrone longo lanceolato-obovati*, siccitate omnino valde *tuberculato-rugosi*.

Hæc species habitu foliisque *R. africanam* refert, sed per foliorum segmenta latiora, per sepala orbicularia nec ovalia, per corollam haud gracilem calcare brevi præditam satis differt. *R. decipiens* foliis deltoideis, sepalis ovalibus, corollâ longius calcaratâ, fructibus multo majoribus facile separanda est, atque *R. cerefolia* per folia magis decomposita laciniis parvis angustis prædita, per sepala angusta, per corollam longe calcaratam apice breviter purpureo-maculatam et per fructûs subellipticos acuminatos omnino diversa est.

R. speciosa rupes ad fluminis Minæ cataractam prope Mascaram (ap. Pomel), ad Saidam et forsan ad locos alios in provinciâ Oranensi Algeriæ habitat.

No authentic or satisfactory material of this plant has been seen, but Warion's Saida example at Kew, although in a fragmentary condition, appears clearly referable to it and has been cited accordingly. The specific diagnosis given above is based on the work of Pomel, collated with this exsiccata. Another example at Kew, one of two labelled "*F. corymbosa*—Munby, Tlemcen," may also belong to this species, which it closely resembles in foliage, while its fruits, which are not large, agree in form with Pomel's description. Unfortunately this specimen now shows no trace of flowers.

Subsectio **POMELIANÆ**.

Foliorum lobi lati. Flores pallide purpurei.

18. Rupicapnos Pomeliana, sp. nov. (Pl. **9**, fig. 4.)

R. africana, Pomel, Nouv. Mat. Fl. Atlant. i. 240 (1874), nomen abortivum; *Fumaria africana*, Coss. Comp. Fl. Atlant. ii. 80 (1883–1887), ex parte; Batt. & Trabut, Fl. d'Alger. i. 25 (1888); non *F. africana*, Lamarck.

Exsicc. Bourgeau, Pl. d'Alger. 1856, Garrouban, in Hb. Mus. Paris (pro maj. parte), ut *Fumaria corymbosa*!

Rupicapnos perennis, glauca, caudice crassiusculo, ramoso, brevi vel paulo elongato, decumbente, tandem vestigiis petiolorum emarcidorum donato, caulibusque semper brevibus. *Folia* pleraque subradicalia, glauca, carnosa, 10–20 cm. longa (petiolo incluso), longe petiolata, *oblonga*, foliolis late obovatis breviter petiolatis et segmentis secundariis subimbricatis raro alternantibus in *lobos rotundatos* vel obovatos *obtusos* vix mucronulatos sæpe incisos irregulariter fissis *2-pinnatisecta subquinata*. *Racemi* corymbiformes, *multi*-(circa 20-) *flori*, cum pedunculo (ad 6 cm. longo) *foliis subduplo breviores*. *Bracteæ* 2–2·5 mm. longæ, *late ovales*, cuspidatæ, apicem versus dentatæ; *pedicelli fructiferi graciles* (fere filiformes), apice incrassati, flexuosi, *infimi ad 25 mm. longi*. *Sepala 3–3·5 mm. longa, fere 3 mm. lata, suborbicularia* (corollæ tubo latiora), peltata vel cordata, breviter acuminata, præsertim basin versus *inciso-dentata*, præter nervum dorsalem latum rubicundum purpurascentia. *Corolla magna*, 12–14 *mm.* (15 mm. ap. Pomel) *longa*, plus minusve gracilis, *pallide purpurea*; *petalo superiore* marginibus apice parum dilatatis subpatentibus vel deflexis (nonnunquam paulo sursum recurvatis) *anguste oblongo obtuso*, carinâ viridiusculâ petali apicem vix attingente, *calcare brevissimo* (2–3 mm. longo) rotundato curvato; *petalo inferiore* marginibus patentibus apicem versus vix dilatatis *lineari-oblongo* nec subspathulato, *obtusiusculo*, ad basin ipsam *gibboso-saccato*; *petalis interioribus* sursum curvatis *apice modice alatis atropurpureis*. *Fructûs majusculi*, sine mucrone 2·5–2·75 mm. longi ac lati, verisimiliter *subrotundo-obovati* (fere ovales ap. Pomel), *cum mucrone brevi obtusissimi* et inferne angustati, satis compressi et valde carinati, siccitate omnino *grosse* et elevato *tuberculato-rugosi*.

Hæc planta per foliorum lobos latissimos rotundatos, per bracteas latissimas atque per flores purpureos brevissime calcaratos sepalis suborbicularibus præditos ab hujus gregis speciebus aliis specifice differre videtur.

R. Pomeliana rupes ad Garrouban et forsan ad locos alios in provinciâ Oranensi Algeriæ habitat.

This plant is identified by Pomel with the original *Fumaria africana*, Lamk. It has been shown, however, that the descriptions of Lamarck and Desfontaines can be definitely determined to refer to another species, albeit the name of *F. africana* was subsequently extended by Cosson to cover in an aggregate sense practically all the forms of the present section. As the specific epithet "*africana*" must be retained for the form originally so described, and the plant so named by Pomel is distinct and has not been otherwise distinguished, a fresh epithet becomes necessary for the latter. It is therefore proposed to commemorate Pomel in its new name.

It is noteworthy that while Pomel's diagnosis of this plant agrees well with the Garrouban exsiccata in Herb. Mus. Paris, the examples seen from other localities which he cites (Tlemcen, Nedroma, and Oran) show different characters and seem to belong to other species. Of these, the Oran plant

which is less sparingly represented in herbaria than the other forms of the genus and agrees with none of Pomel's diagnoses, is accordingly separated as a new species. It is of course possible that the forms from these localities that came under the notice of Pomel were identical with the Garrouban example, for it is almost certain from the mixtures observed in exsiccata that different species of this genus grow in company. But if so, it is curious that Pomel, who apparently knew Oran well, should not have met with the plant that has been most generally obtained there by other collectors.

19. RUPICAPNOS ORANENSIS, sp. nov. (Pl. 9, fig. 5.)

Fumaria africana, Coss. & Dur. in Bull. Soc. Bot. Fr. ii. 305 (1855), ex parte; Coss. Comp. Fl. Atlant. ii. 80 (1883–1887), ex parte, non Lamarck; *F. corymbosa*, Hammar, Mon. Fumar. 42, excl. syn. et loc. Alhaurin (1857), non *F. corymbosa*, Desfontaines.

Icon. Hammar, *l. c.* tab. v, ut *F. corymbosa* (sed petalo inferiore haud saccato).

Exsicc. Balansa, Pl. d'Alger. 1852, No. 337, ut *F. corymbosa*! Munby, Pl. Alger. 1850, No. 38, ut *F. corymbosa*! Bourgeau, Pl. d'Alger. 1856, No. 181, Nedroma (partim, sed non in Hb. Mus. Paris), ut *F. africana*! Faure, Pl. d'Alger. 1904, Oran, ut *F. africana*!

Rupicapnos perennis sed a primo anno jam florens, glauca, radice elongatâ, caudice crassiusculo ramoso decumbente brevi vel paulo elongato, caulibus semper brevibus nonnunquam fere nullis. *Folia* pleraque subradicalia, glauca vel glaucescentia, plus minusve carnosa, 10–30 cm. longa (petiolo incluso), longe petiolata, *oblonga*, foliolis fere ovatis infimis breviter petiolatis reliquis subsessilibus et segmentis secundariis subflabellatis sæpius alternantibus in *lobos obovatos* vel oblongos *obtusos mucronatos* vel subacutos sæpe incisos irregulariter fissis *2-pinnatisecta*. *Racemi* corymbiformes, *multi-*(10–30-, sæpius plus 20-) *flori*, cum pedunculo (ad 5 cm. longo) *foliis* sæpissime *plus duplo breviores*. *Bracteæ* 1·5–3 mm. longæ, *oblongæ*, acutæ rarius acuminatæ, interdum sparsim serrulatæ, verisimiliter purpurascentes; *pedicelli fructiferi graciles* (fere filiformes), apice incrassati, flexuosi, infimi *usque ad* 40 *mm. longi*. *Sepala minima*, 2–2·5 *mm. longa*, 1·5–1·75 *mm. lata*, *ovata*, peltata vel cordata, acuta, basin versus irregulariter *crenato-dentata*, præter nervum dorsalem latum rubicundum purpurascentia, facile caduca. *Corolla maxima*, 12–16 *mm. longa*, ut videtur carinis viridibus *pallide purpurea*; *petalo superiore* marginibus apicem versus paulo dilatatis sæpius sursum recurvatis purpurascentibus *oblongo obtusissimo*, *calcare longiusculo* (4–5 mm. longo) curvato apice rotundato (in formis umbrosis breviore); *petalo inferiore* marginibus latiusculis patentibus apicem versus sensim paulo dilatatis *lineari-oblongo* vix subspathulato *obtusiusculo*, *ad basin* ipsam sæpissime plane *gibboso-saccato*; *petalis interioribus* sursum curvatis *apice modice alatis atropurpureis*.

Stylus malleiformis. *Fructûs magni*, sine mucrone 3–3·25 mm. longi, 2·5–2·75 mm. lati, *ovali-obovati, cum mucrone conspicuo obtusissimi* et inferne multo angustati (supra medium latissimi), plane compressi et valde carinati, siccitate omnino *grosse tuberculato-rugosi*.

Hæc species foliorum lobos latos et flores pallide purpureos *R. Pomelianæ* habet sed bracteis sepalisque multo angustioribus, petali superioris calcare subduplo longiore et fructibus plane longioribus satis differre videtur.

R. oranensis vicinitatem oppidi Oran, Nedromam, Tlemcen ut videtur, et probabiliter alios locos in parte septentrionali provinciæ Oranensis Algeriæ habitat.

This plant, which is better represented in the herbaria consulted than any other member of the genus, is rather inexplicably unnoticed by Pomel, unless it is intended to be included with the previous species *R. Pomeliana*, as may perhaps be inferred from the localities cited. It is not easy to adopt this view, however, seeing how clearly Pomel's description accords with the features of the Garrouban plant in Herb. Mus. Paris and how widely it differs in several particulars from *R. oranensis*. On the other hand, as already remarked under *R. Pomeliana*, it seems impossible that Pomel was unacquainted with this plant in the neighbourhood of Oran.

In shaded situations the foliage of *R. oranensis* becomes lax with relatively thin leaflets, somewhat acutely and by comparison narrowly lobed, while its flowers tend to be reduced in size, with no upward recurving of the margins of the upper petal, and a shorter, straighter spur. These features may be seen in some of the specimens sent out by Balansa, by Bourgeau, and by Faure. Munby's plants, on the other hand, are mostly very dwarf examples, probably collected in dry and exposed rock-fissures, and their clusters of well-developed flowers almost equal the much reduced leaves, of which the segments are thick in texture and very small.

Judging from exsiccata, the flowers of *R. oranensis* appear to be of a paler purple colour than those of *R. Pomeliana*, and they are less concolorous, the margins of the upper petal being sometimes distinctly flushed with a deeper tint, recalling the coloration of the flowers of *Fumaria agraria*.

There is a specimen of this plant at Kew from Munby's herbarium, associated with another which may be *R. speciosa* and labelled "Tlemcen," but it appears uncertain from the arrangement of other examples on the sheet whether it really came from this habitat or whether a transposition of specimens has not at some time taken place.

[20. Rupicapnos ochracea, Pomel, Nouv. Mat. Fl. Atlant. i. 242 (1874); n. v. *Fumaria ochracea*, Batt. & Trabut, Fl. d'Alger. i. 25 (1888); *F. africana*, Coss. Comp. Fl. Atlant. ii. 80 (1883–1887), ex parte, non Lamarck.

Foliorum segmenta in *lobos parvos obovatos* vel oblongos spathulatos fissa.

Bracteæ lanceolatæ, integræ; *pedicelli graciles* apice breviter incrassati. *Sepala minima, lanceolata, valde denticulata*, quam corollæ tubus multo angustiora. *Corolla* circa 12 *mm. longa*, gracilis, *pallide ochraceo-purpurea*; petali superioris margines apice parum dilatati; *calcar longiusculum* (circa 4 mm. longum), apice rotundatum; *petala interiora apice purpurea. Fructûs* angusti, *cum mucrone gracili fere oblongi*, inferne in stipitem distinctum angustati, siccitate *rugosi*.

R. ochracea rupes calciferas ad Goudjilam prope Tiaret in parte orientali provinciæ Oranensis Algeriæ habitat.

This plant, of which no material has been seen, seems essentially distinct from the other species of this section owing to its peculiarly coloured and much smaller flowers, and its narrow fruits. It may possibly be regarded as intermediate in characters between *R. oranensis* and *R. erosa*.]

EXPLANATION OF THE PLATES.

Plate 9.

Fig. 1. Flower of *Fumaria agraria*, Lag., with transverse section near the apex.
Fig. 2. Flower of *F. capreolata*, Linn., do. do.
Fig. 3. Flower of *F. Gussonei*, Boiss., do. do.
Fig. 4. Flower of *Rupicapnos Pomeliana*, sp. nov., do. do.
Fig. 5. Flower of *R. oranensis*, sp. nov., do. do.
Fig. 6. Flower of *R. numidica*, Pomel, do. do.
Fig. 7. Flower of *R. caput-plataleæ*, Pomel, do. do.
Fig. 8. A fully developed flower of *Fumaria sepium*, Boiss.; drawn from a specimen collected at the *locus classicus*.
Fig. 9. A depauperate flower of the same.
Fig. 10. A completely cleistogamic flower of *F. muralis* subsp. *Boræi*; from a cultivated specimen.

Detached flowers all enlarged × 2·5. A=keel; B=wing or margin.

Plate 10.

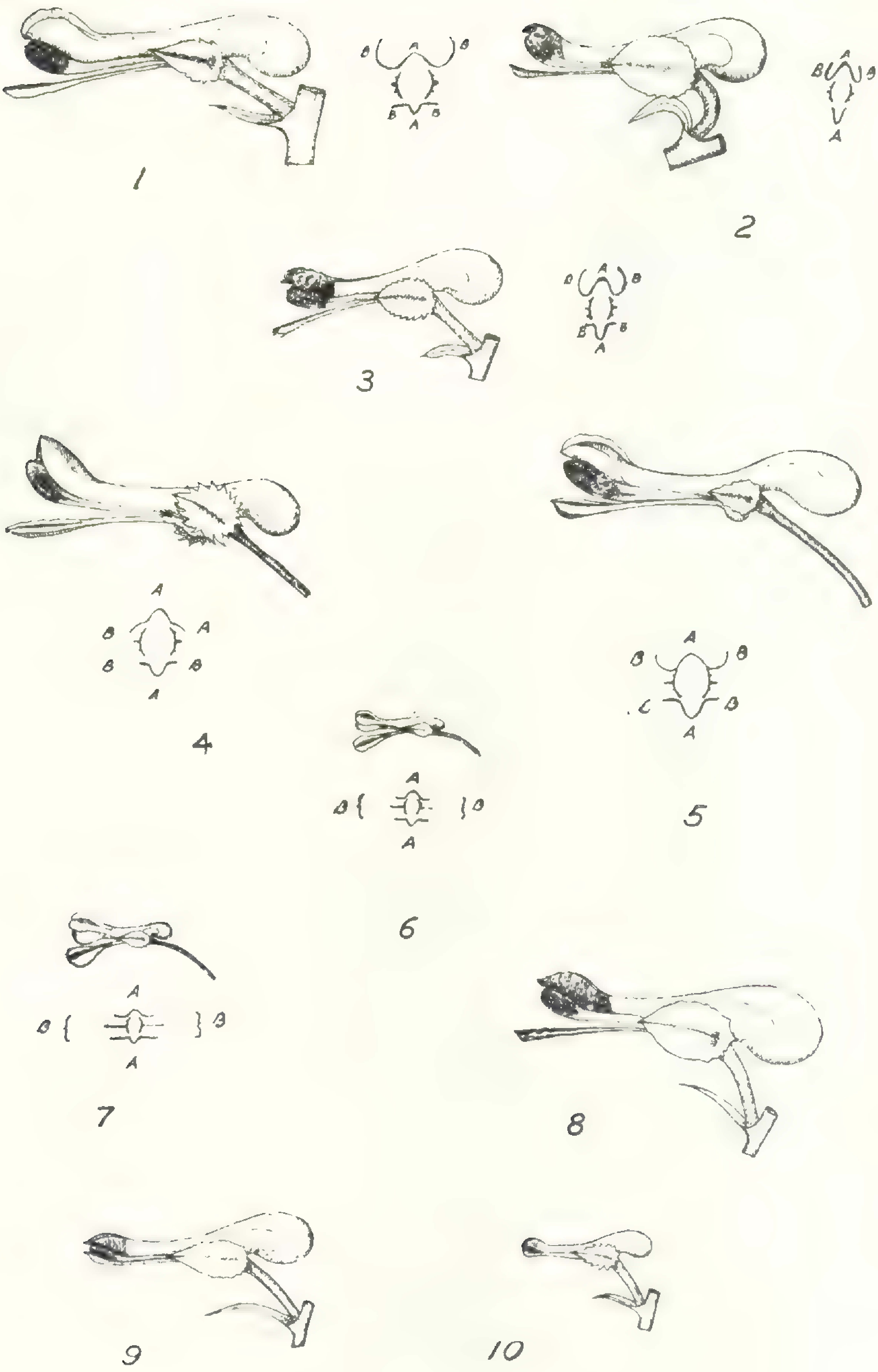
Fumaria Ballii, sp. nov., natural size, with detached flower and dried fruit (×2·5); drawn from the unique specimen at Kew.

Plate 11.

Fig. 1. *Fumaria berberica*, sp. nov., natural size, with detached flower and dried fruit (× 2·5); drawn from a specimen at Kew.
Fig. 2. *F. montana*, J. A. Schmidt, natural size, with detached flower and dried fruit (× 2·5); drawn from Schmidt's original specimen at Vienna.

Plate 12.

Fumaria coccinea, sp. nov., natural size, with detached flower and dried fruit (×2·5); drawn from a specimen collected by Messrs. Sprague and Hutchinson (no. 1265).



H. W. P. del. Grout, sc.

1-3 & 8-10. FLOWERS OF FUMARIA. 4-7. FLOWERS OF RUPICAPNOS.

H. W. P. del.

Grout, sc.

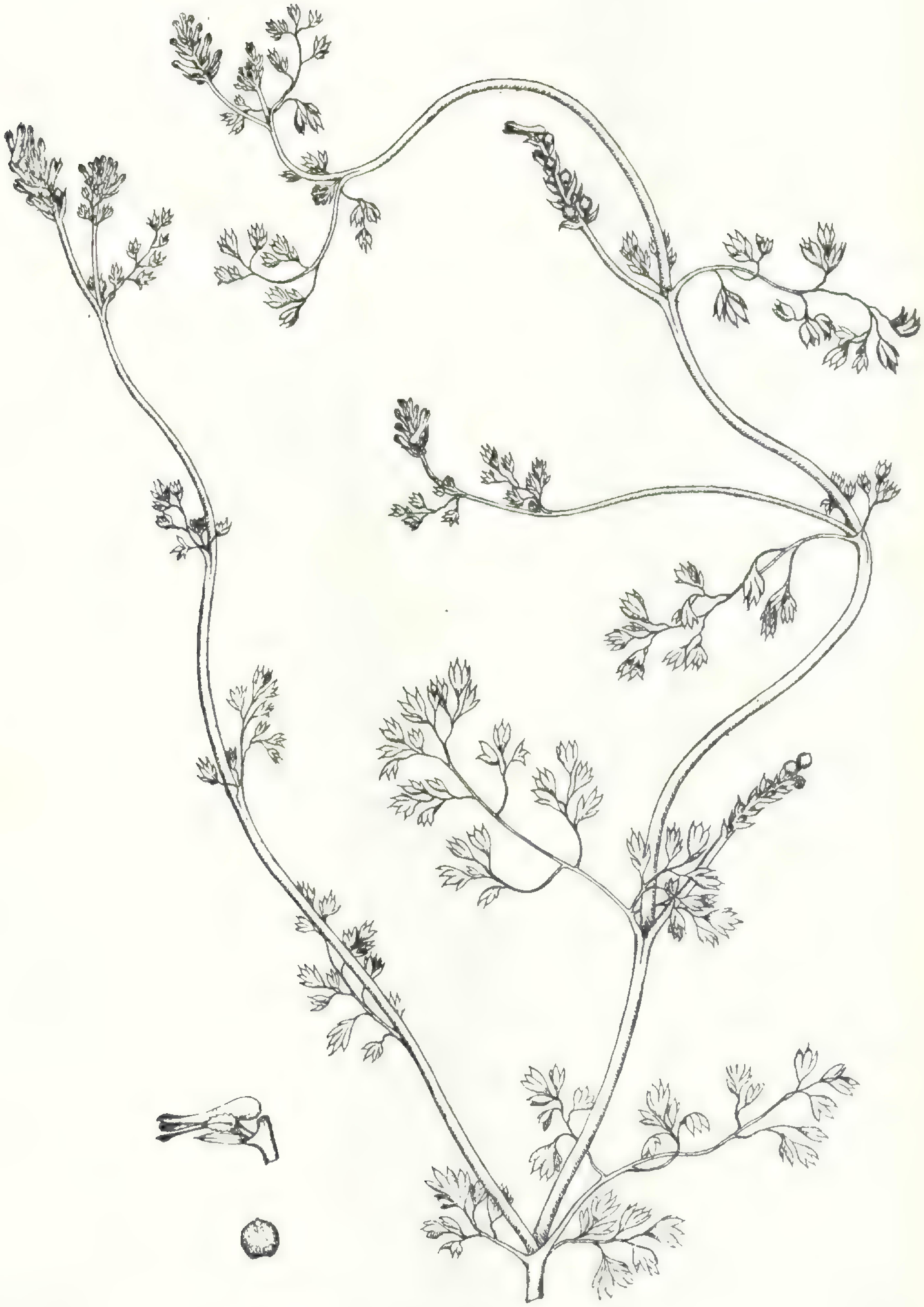
FUMARIA BALLII, sp. nov.

H. W. P. del. Grout, sc.

1. FUMARIA BERBERICA, sp. nov. 2. F. MONTANA, J. A. Schmidt.

H. W. P. del. Grout, sc.

FUMARIA COCCINEA, sp. nov



H. W. P. del. Grout. sc

FUMARIA AUSTRALIS, sp. nov.

H. W. P. del. Grout, sc.

1. RUPICAPNOS MURICARIA, Pomel. 2. R. PRÆTERMISSA, sp. nov

H. W. P. del. Grout, sc.

1. RUPICAPNOS LONGIPES, Pomel. 2. R. SUBLÆVIS, sp. nov.

H. W. P. del. Grout, sc.

RUPIÇAPNOS SARCOCAPNOIDES, Pomel.

PLATE 13.

Fumaria australis, sp. nov., natural size, with detached flower and dried fruit (× 2·5); drawn from a specimen at Kew (Volkens, no. 953).

PLATE 14.

Fig. 1. *Rupicapnos muricaria*, Pomel, natural size, with detached flowers and dried fruit (× 2·5); drawn from a specimen in Herb. Mus. Manchester (Chevallier, no. 397).

Fig. 2. *R. prætermissa*, sp. nov., natural size, with detached flowers and dried fruit (× 2·5); drawn from a specimen in Herb. Mus. Paris.

PLATE 15.

Fig. 1. *Rupicapnos longipes*, Pomel, natural size, with detached flowers and dried fruit (× 2·5); drawn from a type-specimen in Herb. Mus. Paris.

Fig. 2. *R. sublævis*, sp. nov., leaf and fruit (× 2·5); drawn from a specimen in Herb. Mus. Paris.

PLATE 16.

Rupicapnos sarcocapnoides, Pomel, natural size, with detached flowers and dried fruit (× 2·5); drawn from a type-specimen in Herb. Mus. Paris.

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A Hybrid *Stachys*. By C. E. Salmon, F.L.S.

(With one Text-figure.)

[Read 17th January, 1918.]

For some years I have grown in my garden *Stachys germanica* raised from Oxfordshire seed kindly given me by Mr. S. H. Bickham (see Watson Bot. Ex. Club Rep. 1912–13, p. 405), and close by several flourishing clumps of *Stachys alpina* which came to me from Mr. J. W. White's garden at Clifton, and whose origin was the only British station in West Gloucestershire (Journ. Bot. 1897, p. 380 ; 1898, p. 209).

Early last summer I noticed, in close proximity to the above, a particularly vigorous plant sending up several stems and bearing root-leaves that in colour and hair-clothing could be neither those of *germanica* nor *alpina,* and later, when the plant was in full bloom, which occurred just after the period when *S. alpina* was at its best and before that of *S. germanica,* it became obvious that I had an interesting hybrid between these two species.

The colouring of the plant, as a whole, was almost intermediate between the silvery-grey tone of *germanica* (caused by the abundance of its white silky tomentum) and the comparatively green tint of *alpina.*

On its strong stout stems, between three and four feet high, overtopping both its parents (as they grow in my garden), an abundance of bright flowers were borne, larger than those of either *alpina* or *germanica* and of a different colour. Those of *alpina* are of a dull purple, inclining to brown, and *germanica* has corollas of a decidedly pleasing pink tint ; the flowers of the hybrid were clear bright purple, slightly paler near the throat.

The next step was to ascertain what was known and had been written about this hybrid, and I found it had been described as long ago as 1789 when William Aiton (then of the Royal Gardens, Kew) gave it specific rank as *Stachys intermedia*, with the following diagnosis :—" S. verticillis multifloris, calycibus subpungentibus, foliis oblongis subcordatis crenatis, caule sublanato. Oblong-leav'd Stachys. Nat. of Carolina. Introd. about 1762. Fl. June & July " *.

This description is very good as far as it goes, but there must be some error as regards the country of origin ; neither *S. germanica* nor *S. alpina* (and consequently the hybrid) are known to occur in America. An authentic specimen, probably sent by Aiton himself, may be seen in the British Museum Herbarium labelled : " *S. intermedia.* Hort. Kew. Julio 1764," and this matches my examples extremely well.

* Hort. Kewensis, ii. 301.

Since the above was written, Mr. Britten kindly examined this specimen and reported that after the words "*S. intermedia*" on the sheet, some writing I could not decipher was certainly "MSS.", and that this refers to the Solander MSS. in which the description is found and upon which "Hortus Kewensis," ed. 1, was based. Mr. Britten added this interesting note :—"The name on the sheet *and* the description in the MSS. (vol. xiii. p. 67) are entirely in Solander's hand, so that if you like, you can cite the plant as of [Solander in] Aiton, Hort. Kew. ii. 301.

"Solander, in his MSS., added, *later than the description*, '1764 in Carolina. Catesby.' Consequently I hunted up Catesby's plants and in Herb. Sloane 212, f. 29, I found his specimen, also named by Solander . . . . Whatever this may prove to be, the Kew Gardens plant is the type of *S. intermedia* as the reference to Catesby was added later."

I have looked at this American plant and believe that it is a broad-leaved form of *Stachys palustris*, a frequent species in the Southern States, whereas *S. germanica* and *alpina* are unknown there.

I presume that the plant that occurred in my garden used to be in cultivation at Kew, as it is included in the Kew Handlist of Herbaceous Plants, ed. 1, p. 445, 1895 (as *S. alpina*, L., var. *intermedia*), but it has apparently died out and is not mentioned in the 1902 (2nd) edition. I cannot find the plant included in any of our nurserymen's catalogues that I have come across, nor have I seen it in any gardens with which I am acquainted. Nothing is known of it at the Cambridge Botanic Garden.

On the Continent, however, where the two parents are more widely and abundantly distributed under natural conditions, the hybrid is apparently of quite frequent occurrence in gardens. M. Rouy states that it is often cultivated in gardens (Fl. Fr. xi. p. 308, 1909), and M. Correvon, the well-known horticulturist of Chêne-Bourg, Geneva, writes :—"They all cross very often even in nature. We have in Switzerland *alpino-lanata* and *alpino-germanica*."

Briquet has an interesting note, under *S. alpina* in his "Labiées des Alpes Marit." par. 2. 240, 1893, where he mentions that it crosses particularly readily with *S. germanica*, giving rise to a series of intermediate plants, usually sterile, of which many are cultivated in gardens on account of their beautiful spikes of flowers and velvety foliage.

He mentions the various names that have been given to these hybrids, and remarks that although no specimens have yet been found in his district in a wild state, it is quite likely to occur, as the parents are both found.

He explains Bentham's remark in DC. Prodr. xii. 465 : "I see no definite limit between *S. germanica*, *S. lanata*, and . . . . *S. alpina*," owing to the fact that that author recognized no hybrids in the genus *Stachys*.

Rouy (*l. c.*) has attempted to segregate the hybrid accordingly as it varies towards one parent or the other, using the name *intermedius*, Ait., for the aggregate plant, with synonyms *S. sibirica*, Link, and *S. rosea*, Hohen.

The form which approaches the *germanica* parent he called "*α. digeneus* nob.", founded upon the *S. digenea*, Legué (in Bull. Soc. Bot. Fr. xl. p. 213, 1893), and to this he assigned the synonyms *S. germanica* var. *intermedia*, Boiss., and *S. curviflora*, Tausch.

The form which has more affinity with *S. alpina*, Rouy called "*β. paradoxus* nob.", which he considered synonymous with *S. alpina* var. *intermedia*, Benth., and, doubtfully, *S. urticifolia*, Tausch.

If we follow Rouy, my plant must be placed under his *α. digeneus*, as it possesses a preponderance of the characters of *germanica* and agrees satisfactorily with M. Legué's original description (*l. c.*).

As regards the synonyms mentioned by the authors quoted above, the following notes were made when endeavouring to work out my specimens at the British Museum.

S. sibirica, Link.—This is described in Enum. Hort. Bot. Berol. pars 2, p. 109 (1822), and from the description it is possible it may refer to the hybrid under discussion, but if the figure in Sweet, Brit. Fl. Garden, i. t. 100 (1825) correctly portrays Link's plant (and it is so labelled), then that is a form with remote whorls of flowers even at the summit of the stem, and the clothing of the plant less silky in nature than in my specimens.

Reichenbach's Ic. Crit. iv. t. 328 also figures the *S. sibirica* of Link, but that again differs from my plant in many respects, which tallies far better with t. 327 in the same work, labelled *S. intermedia*, Ait.

S. rosea, Hohen.—Boissier (Fl. Orientalis, iv. 720, 1879) gives this as one of the synonyms of his *S. germanica* var. *intermedia*, and indicates that he has seen a type-specimen. It must not be confused with the *S. rosea* of the latter author (*op. cit.* 725). Hohenacker's description (Enum. Talysch, 300, 1838) is meagre in the extreme, practically a "nomen nudum," and I have not been able to see any specimens.

S. alpina, L., var. *intermedia*, Bentham in DC. Prodr. xii. p. 465 (1848). This has a short description—"major, foliis rugosioribus subtus interdum sublanatis," and a large number of synonyms. We cannot, I think, conclude as Rouy has done, that because the "variety" is placed under *alpina* it indicates a form of the hybrid that approaches more to that parent. Indeed, Bentham adds—"An ad *S. germanicam* melius referenda ?"

Of the synonyms he gives, two strike me as being remarkable—"*S. cretica*, Linn. spec. p. 812, fide descriptionis. *S. orientalis*, Linn. spec. p. 813, fide exempl. Tournef. in h. Banks."

As regards the former, Index Kewensis (ii. 972, 1895) indicates that *S. cretica*, L., Sp. pl. 581 (the Bentham synonym refers to ed. 2 of Sp. pl.) equals "*germanica*, *alpina*" : the Linnean description, however, will not do at all for the hybrid under discussion, but seems to correspond with the fine figure in Sibthorp, Fl. Græca, vi. t. 558 (1827) labelled *S. cretica*.

Concerning *S. orientalis*, here again Ind. Kew. (*op. cit.* 973) refers the Linnean plant to "*alpina*": neither the description nor the plate in Sibthorp (*op. cit.* t. 560) of *S. orientalis* bears this out. Moreover, the Tournefortian example in Herb. Mus. Brit., quoted by Bentham, is clearly not of close relationship with *germanica, alpina,* or *intermedia.*

S. germanica, L., var. *intermedia,* Boiss.—I think it is clear from the description given (*loc. cit.*) that Boissier would include under his name that form of the hybrid which shows more obviously the *germanica* parent.

It might be possible to arrange the rather puzzling synonymy of the hybrid and the varying forms as follows :—

The "aggregate" hybrid :
S. sibirica, Link (1822).
S. alpina, L., var. *intermedia,* Benth. (1848).
S. alpina × *germanica,* Briq. (1893).

"Segregate" A (nearer *germanica*). }
S. intermedia, Sol. in Ait. (1789) *.
S. curviflora, Tausch (1831) (*fide* Rouy).
S. rosea, Hohen. (1838). *non* Boiss.
S. germanica, L., var. *intermedia,* Boiss. (1879).
S. digenea, Legué (1893).
S. intermedius, Ait., var. *digeneus,* Rouy (1909).

"Segregate" B (nearer *alpina*). }
S. paradoxa, Rouy (1893).
? *S. urticifolia,* Tausch (1831).
S. intermedius, Ait., var. *paradoxus,* Rouy (1909).

It may perhaps be of interest to record in tabular form the characteristics of my hybrid as compared with the corresponding features of *S. germanica* and *S. alpina*, observed from growing and dried material :—

S. germanica.	*S. digenea.*	*S. alpina.*
Plant c. 75 cm. in height or more; stem covered with an abundance of dense white silky ± spreading pubescence. No glandular hairs. Whole plant not strongly scented and silvery-grey in appearance.	*Plant* c. 107 cm. in height or more; stem provided with copious white silky ± spreading pubescence mixed with shorter glandular hairs. Whole plant scented as in *alpina* and grey-green in appearance.	*Plant* c. 60 cm. in height or more; stem hairy with ± spreading hairs, the shorter ones (particularly near summit of stem) glandular. Whole plant with strong *S. sylvatica*-like scent and green in appearance.

* It is not the *S. intermedia* of Tenore (Fl. Nap. i. p. xxxiv, 1811–15), which is *S. heraclea,* as Tenore himself afterwards admitted.

S. germanica.	*S. digenea.*	*S. alpina.*
Leaves (basal) ovate-oblong, acute, provided with dense white silky non-glandular pubescence (and thus greyish in appearance) more abundant on lower surface; petioles similarly clothed. Upper leaves and bracts ovate- or linear-lanceolate, decidedly more densely silky than basal. All leaves thick in texture.	*Leaves* (basal) ovate-oblong, $\pm$ obtuse, green and hairy above, usually grey-green below with hairs and $\pm$ silky pubescence and also sessile glands; petioles more silkily hairy than in *alpina*. Upper leaves and bracts narrower than in *alpina* and broader than in *germanica*, decidedly more silkily hairy than basal. Leaves slightly thick in texture.	*Leaves* (basal) ovate, obtuse, green, paler on underside, hairy above, rather less so beneath where there are sessile glands; petioles hairy. Upper leaves and bracts ovate-acute, only slightly more hairy than basal. Leaves thin in texture.
Flowers in whorls forming a dense terminal spike with a few separated whorls below.	*Flowers* in whorls laxer than those of *germanica* and closer near top of spike than those of *alpina*.	*Flowers* in whorls almost all separated, with a few aggregated ones at summit.
Calyx 10–11 mm. long, obconic, teeth triangular-acuminate, usually rather shorter in proportion to calyx than those of *alpina*. Whole calyx (and teeth) clothed with long white ascending silky hairs, with sessile glands but no glandular hairs.	*Calyx* 10–12 mm. long, obconic, teeth triangular-acuminate, as in *germanica*. Whole calyx (and teeth) clothed with long white ascending silky hairs, not quite so dense as in *germanica*, with sessile glands; short glandular hairs present on calyx-teeth, rarely on tube.	*Calyx* 10–11 mm. long, campanulate, teeth broadly triangular (more abruptly pointed than in *germanica*) acuminate or mucronate. Whole calyx (and teeth) hairy with ascending-patent hairs, mixed with shorter glandular ones; sessile glands also present.
Corolla pale purple or rose-pink; upper lip arched, c. $\frac{2}{3}$ as long as calyx, with long white silky hairs projecting considerably beyond tip; lower lip slightly longer than upper, $\pm$ entire or crenulate. Hairs in corolla-tube about halfway down.	*Corolla* bright purple, paler near throat, larger than in *germanica* or *alpina*; upper lip arched, c. $\frac{2}{3}$ as long as calyx, with long white hairs (not quite so dense as in *germanica*) projecting considerably beyond tip; lower lip considerably longer than upper, $\pm$ entire or crenulate, broader than in *germanica* or *alpina*. Hairs in corolla-tube about $\frac{3}{4}$ way down.	*Corolla* dull brownish-purple; upper lip flat, c. $\frac{1}{2}$ as long as calyx, with dense hairs, shorter than those of *germanica*, projecting beyond tip; lower lip considerably longer than upper, $\pm$ emarginate. Hairs in corolla-tube near the base.
Stigma white.	*Stigma* almost white, faintly tinged with purple.	*Stigma* purplish.
Ripe seeds smooth, almost black (blackish brown), c. 2 mm. long.	*Ripe seeds* rather more coarsely rugulose than in *alpina*, brown, c. $2\frac{3}{4}$ mm. long. Only one seed usually fertile in each calyx.	*Ripe seeds* usually minutely and irregularly rugulose, brown, c. $2\frac{3}{4}$ mm. long.

If one sums up the various differences enumerated above, it will be seen that by far the larger proportion of the characters of the hybrid in my garden are those of *germanica* rather than *alpina*, the last-named showing itself in (1) the strong peculiar scent of the leaves, (2) the presence of glandular hairs, and (3) the characteristic seed.

FIG. 1.

a. Stachys germanica, flower and seed.
b. S. digenea, ditto.
c. S. alpina, ditto.
All enlarged.

It is, I think, rather a remote hope that the hybrid described may be found in a wild state in these islands, for the only station for *Stachys alpina*, which is in West Gloucestershire, lies some 30 miles away, in a west-south-westerly direction, from the nearest known locality for *S. germanica* in Oxfordshire.

I do not know, however, the limits as regards the carriage of pollen by insects and the distances proved to have been covered.

I wish to thank Mr. Britten, Mr. Skan, and Mr. J. W. White for help in the preparation of this note, and to say that I shall be happy to supply seeds of the hybrid as far as the stock will allow.

A Revision of some Critical Species of *Echium*, as exemplified in the Linnean and other Herbaria; with a Description of *Echium judæum*, a new Species from Palestine. By C. C. LACAITA, F.L.S.

[Read 6th June, 1918.]

INTRODUCTORY.

THE five papers collected under the above title are offered as a quarry, from which any future monographer of the genus *Echium* may dig material. They are:—

1. Five Critical Species of *Echium*: *E. judæum*, mihi, *E. australe*, Lam., *E. Coincyanum*, mihi, *E. pycnanthum*, Pomel, *E. salmanticum*, Lag., pp. 366–379.
2. The Genus *Echium* in the Herbaria of Tournefort, Jussieu, and Lamarck, pp. 379–384.
3. The *Echia* of Sibthorp's Herbarium, pp. 384–392.
4. The Linnean Species of *Echium*, pp. 392–427.
5. The *Echia* of Miller's 'Gardener's Dictionary,' pp. 427–438.

The European *Echia* have been very badly treated by Linnæus. Out of the nine species mentioned by him or existing in his herbarium, one, *rubrum*, Jacq., though represented by no less than three specimens, seems entirely to have escaped his notice, the older synonym for it being twice quoted, but each time under a different species. Two others, *creticum* and *violaceum*, are such hopeless entanglements of contradictions that neither name can be used and both must be abandoned. *Lusitanicum*, though recognisable with certainty from the synonyms and the specimen, is grossly misdescribed. There only remain *vulgare*, *italicum*, *pyrenaicum*, and *plantagineum*, of which the descriptions are quite clear, though with regard to the last three tedious discussions are necessary to clear away the cobwebs spun by later botanists.

Subsequent authors never studied this genus seriously till de Coincy took it in hand. His valuable papers, some of them posthumous, are scattered in Morot's 'Journal de Botanique,' in Bull. Herb. Boiss., in Act. Congr. Internat. 1900, and elsewhere. His death was a grave loss, but unfortunately he never consulted the Linnean specimens, or those of other old herbaria in England, nor does he quote a sufficient number of well-known exsiccata to make his views quite clear in all instances. I have been obliged to differ

with him altogether in the cases of *E. australe* and *E. pyrenaicum*, and to a lesser degree in regard to *E. pustulatum*. He seems to have devoted most attention to the species of Algeria, but his chief discovery was the difference in the arrangement of the scales in the corolla-tube, from which the veins take their origin. In accordance with this he divides the genus into the Sections *Gamolepis* and *Eleutherolepis* ("Sectionnement du genre *Echium*" in Act. Congr. Internat. Bot. 1900, pp. 346–350), though admitting that one or two species, particularly *E. maritimum*, Willd. (*E. confusum*, Coincy), are ambiguous and variable in respect of that character.

The structure of the inflorescence in the genus *Echium* was studied by Kaufmann (see his paper "Ueber die Entwickelung der *Cyma scorpioidea* bei den Borragineen" in Bot. Zeit. xxvii. p. 886, 1869). What the older authors called "spikes" in this genus are really what the Germans term "Wickeln." The Latin *cincinnus* is employed to express the same idea, but I do not find that any satisfactory English equivalent has come into use. "Curl," which is the literal translation of *cincinnus* does not exactly correspond to *Wickel*. I would suggest "furl," which is all the more suitable because, not being a word in common use, it does not suggest any false connotation *. At any rate, the verb "unfurl" exactly expresses what happens to the *cincinni* as they develop from bud to fruit. The word "cyme," used by de Coincy and other moderns, is not suitable, for, although the structure is one of the cymose arrangements, the word itself, as applied to the visible result of the structure, conveys to the mind a picture very different from that presented by the inflorescence of any *Echium*.

De Coincy, in the same paper on "Sectionnement," and in his note on *E. simplex* in Bull. Hb. Boiss. 2, iii. p. 276 (1903), has given an admirable account of the arrangement of the flowers in the *cincinnus*, explaining how the difference in the several laciniæ of each calyx depends on the exact position of the flower relatively to the rachis, on which their disposition is distichous and subunilateral.

Most European species of *Echium* have been described as biennials, though Coutinho, Fl. Port. (1913), more judiciously marks them ⊙ or ♂ with the exception of *lusitanicum* (*Broteri*), *polycaulon* (*salmanticum*), and *rosulatum*, which are certainly perennial, and *parviflorum*, which is always annual. But *arenarium*, *australe*, *flavum*, *grandiflorum*, *italicum*, *planta-*

* I must enter a protest against the growing pedantic misuse of the term "connote," especially by writers on scientific subjects, in the sense of plain English "mean" and occasionally even in the sense of "denote." The name *Echium* denotes all the plants of the genus, but connotes the generic characters. The use of the word as an English logical term was introduced by James Mill, and is explained in Mill's 'Logic,' i. 2, § 5. *Connotare* was used by the schoolmen in the 14th Century, but not in the precise sense of the Mills. See, farther, in Murray's Eng. Dict. sub voc. "*connotative*" and "*connote*."

gineum, *pomponium*, *pustulatum*, *pyrenaicum*, *rubrum*, *tuberculatum*, and *vulgare* seem to behave as annuals or biennials, according to circumstances. In December, 1917, I was able to observe carefully large numbers of *italicum*, *pyrenaicum*, *plantagineum*, and *pustulatum* around Rome and near Taranto. In every case I found that the plant which had flowered in the summer was a dead skeleton with a rotten root. There were no living plants of any of those species, except baby seedlings, which would undoubtedly flower and perish in their turn within 12 months. But in cultivation, and in climates with a less prolonged summer drought, the evidence seems to point to a biennial habit, with two possible flowering seasons. *Echium angustifolium*, Mill., on the other hand, appears to have taken the opposite course, for whilst Miller grew it as an annual at Chelsea, we are assured by Halácsy that in Greece it (*E. elegans*) is perennial.

The presence of hairs on the filaments, an excellent distinctive character for one or two species, has been made too much of by de Coincy for certain others, in which the hairs are very obscure and very few, and not constantly present. On the other hand, he has perhaps underrated differences in the nucules, which serve to separate true *vulgare* from its southern substitutes. The size of the corolla can only be used with reservation as a specific character, for in most, if not all, the species, sexual variation affects the size, sometimes to an extreme degree, as in so-called *E. Wierzbickii* and in the pistillate form of *E. setosum*, Vahl. Colour is more reliable, but dangerous to depend on in dried specimens, especially if these have been exposed to the action of any acid. And it is to be borne in mind that the blue kinds often throw white or pink individuals.

Echium rubrum stands by itself on account of its undivided style with a capitate stigma. It is strange that this character should not have been noticed by Jacquin himself or by De Candolle in the 'Prodromus.' It would be an exaggeration to create a new monotypic genus on this ground, but it necessitates some modification of the received generic definitions of *Echium*. De Candolle, Prodr. x. p. 16, says: "stigma bipartitum, stylo nempe apice bilobo, lobis filiformibus"; the accurate Bentham, in Gen. Pl. ii. p. 863, "stylus filiformis, apice breviter 2-fidus, stigmatibus parvis." Gürke in Engler's 'Pflanzenfamilien,' iv. 3, p. 128, merely translates Bentham's Latin into German, without addition or subtraction of a syllable.

In the course of my researches I have seen all the specimens of the genus in the following herbaria, besides my own:—

1. Kew.
2. British Museum.
3. Sibthorp's, Sherard's, and Dillenius's plants at Oxford.
4. The Bailey herbarium now in the Museum of Manchester University.

5. Herb. Mus. Paris, including the collections of Tournefort, Lamarck, Jussieu, and de Coincy. I had not time to go through the specimens of herb. Cosson, now at the Museum, which are indispensable for Algerian species.
6. Herb. Bonaparte which includes herb. Rouy.
7. Erbario Centrale Italiano at Florence, and Desfontaines's specimens in herb. Webb.
8. The herbarium of the University of Rome.
9. Tenore's and Gussone's herbaria at Naples.

I have been sent a few specimens through the kindness of M. Sudre of Toulouse, Prof. Coutinho of Lisbon, and Prof. Henriques of Coimbra. To these gentlemen I must express my gratitude, and above all to M. Henri Lecomte and his assistants at the Paris Museum, and to Prince Roland Bonaparte, who so generously allows access to his magnificent collections. My thanks are also due to many in Italy and at home, particularly to Dr. Daydon Jackson, whom I have troubled with endless small inquiries, and to Mr. Wilmott at the British Museum for the assistance of his younger eyes and for counsel, perhaps not always followed, as to technicalities of nomenclature.

I.

FIVE CRITICAL SPECIES OF *ECHIUM*.

Echium judæum, sp. nov.

Among the specimens of *Echium* from Palestine in the herbaria of the British Museum and Kew are several labelled *plantagineum* (or *violaceum* in the same sense), although differing altogether from that species in their indumentum, which is not homogeneous but dimorphous, in the shape of the bracts, and in the corollas which are more obliquely cut, but less wide at the throat, and covered with soft pubescence instead of being glabrous with only some long hairs on the veins and ciliæ on the margin. In fact, the nearest species is not *E. plantagineum* but *E. grandiflorum*, Desf., to which *E. judæum* bears a considerable resemblance, but the filaments are glabrous, at any rate, as seen without the microscope, whereas in *grandiflorum* they are constantly furnished with scattered transparent hairs, longer than the breadth of the filament itself.

E. judæum, mihi ; Sect. *Eleutherolepis*, Coincy.

Radix fusiformis, illæ *E. vulgaris* similis. Caules plerumque simplices, erecti, c. 35 cm. alti, indumento dimorpho, sc. pubescentia creberrima, brevi, grisea, et pilis longioribus, sparsis, albis, substrigosis. Folia radicalia (in exempl. unico ex Hierosolyma præsentia) petiolata, ovalia, medio nec basi latiora, 14 × 4½ cm. ; penninervia, nervis utrinque 6–8,

ante marginem evanidis, non anastomosantibus; caulina inferiora petiolata, anguste elliptico-oblonga; 5–10 cm. longa, 1–2 cm. lata; suprema sessilia, sæpe exacte lanceolata. Foliorum indumentum caulino simile, sed pilis rarioribus tuberculo mediocri insidentibus. Tubercula magis quam in *E. grandifloro* conspicua, illis *E. pustulati* minora. Inflorescentia e cincinnis axillaribus simplicibus quaquaversis constans, virgineis valde scorpioideis, in fructu elongatis erecto-patulis. Flores in cincinnis 20–40, sessiles, distichi sed unilaterales, bracteati sed infimo sæpe ebracteato (folio caulino supposito bracteæ officio functo), initio conferti, serius inter se remotiusculi. Bracteæ lanceolatæ; nonnullæ basi parum latiores at in acumen productæ. Calyx sericeo-pilosus, pilis albis, usque ad 2–3 mm. longis, pro genere mollibus, haud aut vix strigosis; laciniæ lineares, usque ad 12 mm. longæ, sed tubo corollino multo breviores, post anthesin non ampliatæ nec (ut in *E. amœno*) longe concretæ, tubo tantum in fructu incrassato. Corolla ore obliquo, illæ *E. grandiflori* haud absimilis, in sicco 3–4 cm. longa; pubescentia minuta, albo-grisea, et secus nervos pilis nonnullis longioribus vestita, margine non ciliata. Color in sicco violaceo-purpureus vel fasciis roseis et pallide cæruleis alternantibus. Stamina inclusa, vel duo longiora ultra labium inferius brevissime exserta, filamentis glaberrimis violaceis, antheris ovoideis, impuberibus amœne cæruleis, serius lutescentibus. Stylus hirsutiusculus, violaceus, apice ad circa 2 mm. (multo minus profunde quam in *E. amœno*) bifidus, initio vix aut parum exsertus, postea elongatus. Nuculæ videntur (perfectas non vidi) parvæ, 3 mm. longæ, apiculatæ, latere interiore acute carinatæ, tuberculato-rugosæ, pallidæ. Herba exsiccatione virido-grisea, nec, ut in *E. grandifloro*, tabacina.

Differt ab *E. grandifloro*, Desf.:—(1) Foliorum tuberculis majoribus; (2) Bracteis lanceolatis nec lato basi ovatis aut subhastatis; (3) Pilis cincinnorum multo copiosioribus, albis, longioribus, mollioribus, vix strigosis; (4) Calycis laciniis longioribus; (5) Filamentis glaberrimis; (6) Herba exsiccatione non tabacina.

Ab *E. plantagineo*, L. (etiam Palæstinæ incola) longius distat indumento dimorpho, foliis caulinis bracteisque basi non semiamplexicaulibus, corollis magis obliquis sed fauce minus dilatato, passim pubescentibus, non vero ciliatis, staminibus brevioribus.

Habitat in Palæstina. Exemplaria vidi sequentia in herbariis Kewensi et Musei Britannici.

1. Jerusalem, Haram Court; leg. M. J. Fox, ii. 1867 (nom. *E. violaceo*). 2. Kallirhoe; leg. W. A. Hayne, iii. 1872 (nom. *E. violaceo*). 3. Magdala; leg. B. T. Lowne, 1863–1864 (nom. *E. violaceo*). 4. Jericho in desertis; Bornmüller, It. Syriacum, 1897, no. 1136 (nom. *E. plantagineo*). 5. Jericho in stony places; Plant. Palæst. Maris Mortu; leg. Meyers & Dinsmore (nom. *E. plantagineo*). 6. Beirut; Pl. Syriæ littoralis ex herb. Postian, no. 234, v. 1875 (nom. *E. plantagineo*).

ECHIUM AUSTRALE.

What is *Echium australe*, Lam. Ill. i. p. 412 (1791)? De Coincy, in Morot's Journ. Bot. xiv. p. 326 (1900), identifies it with a plant from southern Spain, which I shall call *Echium Coincyanum*, distributed in Bourgeau's exsiccata for 1849, no. 334, and for 1852, no. 1625. In a footnote he remarks, "Cette espèce a été confondue tantôt avec l'*E. creticum*, L., tantôt avec le *grandiflorum*, tantôt avec l'*angustifolium*, Lam. ou Salzm., tantôt avec le *pustulatum laxum*, Herb. Boiss." In spite of my great respect for de Coincy's knowledge of the genus *Echium*, of which he has been the only serious student hitherto, I cannot doubt that in this case he has himself only increased the confusion, for Lamarck's species is quite unlike the Bourgeau specimens, being, in fact, a garden form identical with the specimen of *creticum* in the Linnean herbarium *, and undoubtedly derived from some variety of *E. grandiflorum*, Desf., probably from that which is found on the borders of France and Spain.

Consequently, the names *E. grandiflorum*, Desf. (1798), and *E. macranthum*, Roem. & Sch. (1809) †, must be replaced by that of Lamarck, which, moreover, cannot give way to *E. creticum*, L., for, although the Linnean

* See my paper on the *Echia* of hb. Linn., p. 396.

† The name of *grandiflorum* for Desfontaines's species was altered to *macranthum* by Roemer and Schultes, Syst. iv. p. 20 (1819), "ob *E. grandiflorum* antiquius Andr. et Vent." Rouy, Fl. Fr. x. p. 309, adopts this alteration, also quoting the still earlier *E. grandiflorum*, Salisb. But *E. grandiflorum*, Salisb. Prodr. p. 115 (1796), was only proposed by him as an equivalent for *E. orientale*, L. It was therefore still-born and must be ignored. *E. grandiflorum*, Andr. Bot. Rep. tab. xx. dated May 1st, 1798, is identical with *E. formosum*, Pers. Syn. i. p. 163 (1805), now referred to a different genus as *Lobostemon formosus*, Lehm., and *E. grandiflorum*, Vent. Malmaison, p. 97 (1803), is identical with the *grandiflorum* of Andrews.

The preference of Andrews's name is based on the assumption that it was published earlier than the first volume of Desfontaines's 'Flora Atlantica.' But of this I have not been able to find any evidence. Many copies of the 'Flora Atlantica' bear the date "anno VIII" on the titlepage of both volumes, which has led to that work being referred to the year 1800. These titlepages are false. Earlier copies—for instance, that of the Linnean Society—bear the date "anno sexto reipublicæ gallicæ" in both volumes, which is untrue for vol. ii. Evidence of the true dates is to be found in Cat. Bibl. Banks, vol. v.—itself published in 1800, where at p. 71 the first vol. is said to be of "an VI" and at p. 214 the second is referred to "an VII." Moreover, on p. 458 of the Linnean Society's copy of vol. ii. there is a note in Sir J. E. Smith's hand, "Sept. 25, 1799," proving that that volume cannot have come out later than 1799. Now "an VI" ran from Sept. 1797 to Sept. 1798, so that *E. grandiflorum* in vol. i. p. 166, may well have appeared before May 1st, 1798. Nevertheless, it is strange that Desfontaines himself, in Hist. Arbr. i. p. 177 (1809), should have used the name *grandiflorum* in Andrews's and Ventenat's sense without any allusion to his own *grandiflorum*. At any rate, the priority of Andrews's name is so doubtful that, on the strictest interpretation of the rules, it does not justify the abandonment of so well-known and suitable a title as *grandiflorum*, Desf., for the Algerian *Echium*, especially as its rival is a *Lobostemon*.

specimen is identical with Lamarck's type, *E. creticum*, Sp. Pl., is an intricate and inextricable mixture of the species represented in the herbarium with the totally different *E. angustifolium*, Mill. (non Lam.), =*E. elegans*, Lehm., and is therefore a *nomen confusum* that cannot be employed for any species *. So much the better, for *creticum* would be an objectionable title for *australe*, which is not found in Crete or in Syria, whence Linnæus says that he had his seeds of *creticum*.

Probably de Coincy was led astray by the occasional occurrence of *E. australe* with smaller corollas than those of the typical *E. grandiflorum* of Algeria ; indeed, neither Lamarck's nor Linnæus's specimen has the very long corollas of that form, for which, if a distinctive name is demanded, I think it should be *E. australe*, Lam., forma *macranthum* (Roem. & Sch.), Coutinho, or, perhaps better, forma *grandiflorum* (Desf.). But the corollas are similarly cut in both ; the difference in size is not specific or varietal, nor associated with different geographical areas. It is parallel to the variation in corolla-size, often, perhaps always, sexual, that is so well known in *E. vulgare*, *E. plantagineum*, and *E. maritimum*, and is most remarkably displayed in the Egyptian *E. setosum*, Vahl †. But not all cultivated individuals of *australe* have the reduced corollas. Sweet, Brit. Fl. Gard. t. 101 (April 1, 1825), describes and figures *E. australe* raised from seed received from Germany under that name, showing very long corollas.

E. australe differs from *E. Coincyanum* in the much broader and differently shaped leaves, ovate, or oval narrowing at the base, not oblong ; in their indumentum, which, though varying much in individuals, has not the soft pubescence, "duvet très fin" of de Coincy, to form a carpet beneath the tubercle-borne setæ ; and in the tobacco-like colour of the dried plant, whereas *Coincyanum* keeps greyish. The corollas are differently cut and of a different colour, the rich red tinge of *australe* being traceable even in old exsiccata. The filaments are conspicuously and constantly hairy ; not pubescent, but furnished with long, slender, flexuose, scattered hairs, easily seen even *in sicco*. Sweet, *loc. cit.*, mentions "very hairy filaments." The hairs on those of *Coincyanum* are extremely scarce, not present in every flower, perhaps not even in the majority, and very difficult to observe in herbarium specimens. The fruiting calyces are much wider apart in *australe*, and the nucules remarkably large, as in Algerian *grandiflorum*, twice the size of those of *Coincyanum*. It is unfortunately impossible to distinguish how much of de Coincy's elaborate description of *australe* is drawn from Bourgeau's specimens, and how much from Lamarck's or others of true *australe*.

Lamarck gives very short diagnoses of his species of *Echium* ; of his no. 1860, he only says : " *E. australe* foliis caulinis ovatis, utrinque attenu-

* See my *Echia* of hb. Linn., *infra*, p. 396.

† See de Coincy in Morot, Journ. Bot. xv. p. 322 (1901).

atis, staminibus corollam æquantibus. Ex Eur. austr.? *E. lusitanicum?*" He is obviously describing a garden plant, whose native home he does not know. Scanty though the diagnosis may be, the description of the leaves is sufficient to exclude with certainty *E. Coincyanum*, as represented by the Bourgeau exsiccata, which have oblong stem-leaves, wider or narrower, but not ovate nor attenuate at both ends. This character, in fact, excludes all European and Mediterranean *Echia*, except *E. grandiflorum* and *E. rosulatum*, Lange.

Let us follow the advice of Rouy, Fl. Fr. x. p. 309, note, who, though he adopts de Coincy's wrong identification of *australe* with Bourgeau's specimens, nevertheless recommends us to interpret Lamarck's scanty diagnosis by means of Poiret's good description in Dict. Encyc. viii. p. 672 (1808), which is so precisely applicable to Lamarck's type of *australe* * and to the *creticum* of hb. Linn. that it is worth transcribing :—"Il y a de si grands rapports entre cette espèce et l'*Echium grandiflorum*, qu'on serait tenté d'attribuer leurs différences aux localités ou à la culture. Celle-ci a assez généralement ses fleurs plus petites et ses feuilles plus rudes. Ses tiges sont droites, hautes d'un à deux pieds, rameuses, parsemées de poils rudes, allongés, cendrés ; garnies de feuilles ovales, un peu oblongues, rudes, médiocrement hérissées de tubercules et de poils roides, épars ; à peine veinées, entières, ciliées à leurs bords, rétrécies presque en pétiole à leur base, un peu aiguës ou obtuses à leur sommet ; les inférieures beaucoup plus amples ; les supérieures plus étroites et plus courtes ; celles des derniers rameaux et les florales sessiles, élargies à leur base, presqu'acuminées.

"Les fleurs sont disposées en épis allongés, feuillés, très hérissés ; le calice divisé en cinq découpures droites aiguës ; la corolle d'un grandeur médiocre, un peu pileuse, une fois plus longue que le calice, de couleur violette ou d'un rouge pourpre ; le tube aussi long que le calice ; le limbe tronqué obliquement, à cinq lobes inégaux ; les étamines aussi longs que la corolle, légèrement pileuses, ainsi que le style ; le stigmate bifide.

"Cette plante croit dans les contrées méridionales de l'Europe. On la cultive au Jardin des Plantes de Paris. (V. v.)"

In addition to Bourgeau's examples, de Coincy also quotes for his compound *australe* the specimen so named in Lamarck's herbarium and another in that of Jussieu †. He consequently enlarges his description to include these as well as Bourgeau's, altering the character of the stem-leaves to "ovales ou oblongues" so as to cover both species. But he was aware that Lamarck's and Jussieu's specimens were not identical with Bourgeau's as appears from the following observation : "L'*australe* existe dans l'herbier du créateur de

* See my note on Lamarck's herbarium, specimen no. 15, *infra*, p. 384.

† Both of these I have examined and found identical with each other. One of those in hb. Jussieu, no. 6619, is labelled as coming from the Jardin des Plantes, "ex hort. reg. Paris"

l'espèce, mais, comme il arrivait souvent aux anciens botanistes, il l'a établie sur un exemplaire qui porte les signes évidents de culture. Il s'ensuit que certains caractères ont pu être altérés, c'est ce qui est arrivé pour les feuilles qui sont ovales dans les échantillons des herbiers Lamarck et Jussieu et oblongues dans ceux récoltés par Bourgeau." Just so; but the remark about the leaves is going too far; the species which has been modified by cultivation is the essentially similar "*grandiflorum*," not the essentially different *Coincyanum*.

Then de Coincy goes on: "son inflorescence lâchement paniculée lui assigne une place à part et ne convient à aucune des espèces qui ont été confondues avec elle." This is strikingly true of the Lamarck and Linnean specimens, and also of the more luxuriant individuals of Algerian *grandiflorum*, but does not hold good for Bourgeau's plants, in which the inflorescence shows no marked difference from that of the forms called *pustulatum* by writers on the flora of Spain.

This should be enough to clear the Bourgeau specimens out of the way, and to exclude the possibility of *E. Coincyanum* being the progenitor of Lamarck's *australe*. It remains to consider from what form of *grandiflorum* that garden plant can have arisen. *E. grandiflorum* occurs in five geographical areas: 1. Algeria and the adjacent regions; 2. Sardinia and Corsica; 3. The French department of the Var; 4. North-Eastern Spain and the adjacent district of France; 5. Portugal. Areas 4 and 5 are the most likely to have supplied the seed, and I should have said preferably 4, where individuals almost identical with the cultivated plant occur, but that Lamarck himself has hinted at Portugal. Area 3 is most improbable, because the variety that predominates there is very unlike Lamarck's.

1. The Algerian plant is very abundant and practically only differs from Lamarck's type in its somewhat longer corollas. Desfontaines says: "affine *E. australi* Lam. differt foliis lævibus aut tuberculis vix conspicuis conspersis, corolla duplo triplove majore." The relative size of the corolla is here much exaggerated. Many, though not all, Algerian specimens show leaves with enough tubercles to be undistinguishable from those of Lamarck. As far as habit is concerned, that garden form looks like an extreme case of the more diffuse and broad-leaved Algerian specimens from rich situations. M. Battandier, the father of Algerian botanists, writes "les feuilles varient assez de dimensions suivant que le sol est plus ou moins fertile." There are plenty of Algerian specimens in the herbaria. I will only quote Reverchon, Pl. Alg. 1896, no. 68, from Bougie, and Faure's exsicc. from Oran à Santa Cruz, as luxuriant examples, the latter with smaller flowers than usual. The middle stem-leaves of these are from 2 to 3 cm. broad.

2. I have not seen enough material from these islands to speak of the form that occurs there. Moris indicates *creticum*, in the sense of *australe*, from Sardinia, Fl. Sard. iii. p. 128, tab. xcvii., and his specimens bear out the

determination. In Corsica the species seems to be exceedingly rare. I have only seen one specimen, in hb. Mus. Paris ex hb. Grenier labelled "*E. creticum*, sommet calcaire plus haut du Pic de Pigno sur Nouzo." Viviani, Fl. Cors. Diagn. p. 3 (1824), quotes *macranthum* = *grandiflorum* from Bonifacio.

3. The specimens from the district between Hières and Nice belong to a quite special narrow-leaved variety, which I think merits a name and might be called var. *provinciale*. The stem is erect and the inflorescence narrow. The root-leaves measure 6–10 cm. by 1–2 cm.; those of the stem are only about 5 mm. broad. Their indumentum is softer, and their appearance when dried paler and more buff-coloured than in the other forms. The corollas are of full Algerian size. Of this variety I have seen many examples from the Esterel range, from Agay, Fréjus, Antibes, Roquebrune, Bormes, Hières, and from the summit of the Maures range "à la Sauvette." I do not think that Lamarck's or Linnæus's plant can have arisen from a form so different in leaf-shape, habit, and general facies.

4. The plants of the Spanish borderland are mostly rather diffuse, with broad leaves, rather rougher than those of the Algerian plant, and with corollas of very variable size, some as long as in Algeria, others at least one-third shorter. These are probably the origin of the cultivated plant. But the shorter corolla, as said before, does not indicate a specific difference. Some of the following exsiccata are labelled *australe*, some *creticum*, some *grandiflorum*:—

(*a*) from France.

1. Soc. Dauph. no. 3822 from Banyuls-sur-Mer (in hb. Lacaita).
2. Banyuls; ex. hb. Loret, hb. Timbal-lagrave, and hb. Gautier.
3. Cerbère à la Tour du Midi (in hb. Bonaparte).
4. Vallée de Consolation près Collioure (hb. Mus. Paris).

(*b*) from Spain.

1. Cadaques (Catalonia); Sennen Pl. D'Esp. no. 328 as "*creticum* forma *grandiflorum*."
2. Rosas near Gerona (in hb. Bonaparte).
3. Figueras (hb. Bonaparte).
4. Cambrils (Tarragona) (hb. Bonaparte).
5. Benicarló (Castellon de la Plana) (hb. Bonaparte).
6. Port Bou (hb. Bonaparte).

5. I regret that I have not been able to see any specimens from Portugal, but Coutinho has dealt with the species so well in his Fl. Port. p. 510 (1913), that we may safely accept his view, from which it is clear that Lamarck's plant might have come from Portugal. Coutinho distinguishes two varieties of *australe*: (a) *genuinum*, with branching habit and corollas of 13–20 cm.,

which would correspond to the garden form under discussion, and (b) *macanthum* with simple or nearly simple stems and corollas of 20–30 mm. This may correspond either to the Algerian *grandiflorum* or to var. *provinciale*, but such closer determination is immaterial as far as the plant of Lamarck is concerned.

Among the old specimens in the British Museum there are several that agree with Lamarck's type *, on which Solander has altered his original determination of *creticum* to *australe*, perhaps regarding the name *creticum* as belonging to the very different *E. creticum angustifolium rubrum* C. B. P. = *E. elegans*. There are also two specially interesting examples of *E. australe* Lam. in hb. Gay at Kew, both from the herbarium of L. C. Richard. On both Gay has noted "procul dubio cultum" and added on one label, "Je soupçonne que cette plante est provenue des graines de l'*E. grandiflorum*, Desf.," and on the other "J'ai vu cette plante dans l'herbier du Muséum, dans ceux de Desfontaines, de Jussieu, de Delessert, etc. Tous les échantillons qui s'y trouvent ont été cultivés. Celui de l'herb. du Muséum a été pris au Jardin des Plantes le 3 Juillet, 1813. Tous sont remarquables par leurs feuilles larges, amincies à la base, et par leurs bractées très allongées, les inférieures larges et foliacées." Gay's herbarium also contains the two specimens of Bourgeau's quoted by de Coincy. The determination on their labels, "*E. angustifolium* ? Lam. Salzm.," is due to Gay himself, who was a very close observer, and proves conclusively that he knew they were not *E. australe*, Lam., as grown in the Jardin des Plantes and as represented in herb. Juss. Gay could not have seen Lamarck's type, for in his time Lamarck's herbarium was in Germany.

It will be seen from what has been said that I do not accept the arrangement in Rouy, Fl. Fr. x. pp. 309, 310, where *australe* and *macranthum* are treated as distinct species on the ground of different size of the corollas and of the nucules, without any reference to different leaf-characters. But Rouy has obviously copied his measurements from those of de Coincy, quoting Bourgeau's specimens together with Soc. Dauph. 3822 for *australe*. The nucules described for that species as "très-petites, 2–2½ mm." obviously belong to *Coincyanum* and not to *australe*, Lam. Lamarck's type-specimen of *australe* has no ripe nucules ; see p. 384 below†.

* See a list of these in my *Echia* of hb. Linn., *infra*, pp. 401, 402.

† Since the above was written I have grown *E. grandiflorum* at Selham in Sussex from seed sent by M. Battandier of Algiers. Two sowings were made. The earlier flowered in July and resembled the Algerian plant in habit and size of corolla. But the later-sown plants, which did not begin to flower till September and continued till the hard frosts, were leafy and diffuse, with smaller corollas, exactly resembling the *creticum* of Herb. Linn. and confirming the opinion expressed in the text as to the specific identity of *australe*, Lam., *grandiflorum*, Desf., and *creticum*, Herb. Linn.

ECHIUM COINCYANUM, nom. nov.

Echium Coincyanum, mihi, = *E. australe*, Coincy, Rev. Esp. Crit. *Echium* in Morot's Journ. Bot. xiv. p. 326 (1900), quoad exempla Bourgeauana, Rouy, Fl. Fr. x. p. 309 (1901), non Lam. Ill. i. p. 412 (1791), nec Poir. Dict. Encycl. viii. p. 672 (1808) = *E. creticum*, Nym. Consp. Fl. Eur. p. 515 (1881), et Willk. et Lange, Prodr. Fl. Hispan. ii. p. 487 (1870), pro maxima parte, non L. = *E. angustifolium*, Salzm. (et aliorum) in schedis, non Lam.

In my note on *E. australe*, I have pointed out that de Coincy confused two different species under that name, having united to the true *australe*, Lam., a plant best known from certain exsiccata of Bourgeau, to distinguish which I propose the name *Coincyanum*. It would have been preferable to call this species after M. Bourgeau but for the existence of *E. Bourgæanum*, an arborescent species from Teneriffe.

Echium Coincyanum is based on Bourgeau's no. 334 of the year 1849 from the Tajo de Ronda in Andalusia, no. 1625 of 1852 from the Sierra San Felipe de Jativa, and I may add, though it is not mentioned by de Coincy, his identical no. 989 of 1850 from the Sierra de Segura. The Kew herbarium contains two examples of each of these numbers in excellent condition. No. 334 was determined by J. Gay as "*E. angustifolium*? Lam. Salzm.," meaning that though uncertain whether it really is Lamarck's *angustifolium* (which it is not) he considered it the same plant that Salzmann had collected "ad vias circa Malagam abunde" and labelled "*E. angustifolium*, Lam. DC." This determination of Gay's proves that he knew the plant not to be *E. australe*, Lam. of herb. Juss. etc., and as grown in the Jardin des Plantes. The similar naming of nos. 989 and 1625 is due to Cosson.

I have examined these species with some care. The stem-leaves are not oval but oblong; the corollas are large, 20–25 mm., mostly blue (*in sicco*), not dull reddish as in *E. australe*, and less obliquely cut. The presence of hairs on the filaments of *E. Coincyanum* is not quite certain and should be carefully observed on the living plant. De Coincy says "au moins un des trois filets postérieurs poilus, ordinairement tous les trois," and in a footnote "J'ai trouvé des exceptions." It is impossible to say whether these observations of his were made on specimens of *Coincyanum* or on true *australe*, but I think more probably on *Coincyanum*. In Bourgeau's specimens I could find none on the first examination, when two corollas were boiled for dissection, although I was assisted by the defter fingers and younger eyes of Mr. Hutchinson of the Kew herbarium. Subsequently in a corolla opened without boiling I found a very few sparse hairs on two filaments. My apparently contradictory results seem to agree with de Coincy's. The filaments of *australe*, on the contrary, are always remarkably hairy.

Besides the three Bourgeau numbers, which must be regarded as the types, I consider the following specimens to be referable to *E. Coincyanum* * :—

1. Salzmann in hb. Gay; ad vias circa Malagam; as *E. angustifolium*, Lam.
2. Willkomm anno 1845, no. 902, from Malaga as *pustulatum.*
3. Porta et Rigo, it. ii. hisp., no. 151, from Almeria as *creticum.*
4. Wolley-Dod anno 1912, nos. 412, 473, and 610, from Gibraltar at the Mediterranean steps as *creticum.*
5. Roffey, March 1, 1916 (in hb. Mus. Brit.), from Tajo de Ronda.

I have met with no specimen of *Coincyanum* in the old herbaria earlier than that of Salzmann.

Echium pycnanthum = E. angustifolium, Lam. (1791), non Mill. (1768), nec Thunb. (1811).

Echium angustifolium, Mill. Gard. Dict. (1768), and *E. angustifolium*, Lam. Ill. i. p. 412 (1791), were wrongly synonymised by Poiret in Dict. Encycl. viii. p. 671, since when Miller's species has been entirely ignored or quoted without any discussion of its identity.

It is undoubtedly the plant known to the old botanists as *E. creticum angustifolium rubrum*, C. B. P., and, as I hope I have established in my notes on Miller's *Echia*, is the oldest name for *E. elegans*, Lehm., plentiful in Greece and the Levant. But *E. angustifolium*, Lam., is a totally different species from Spain, closely allied to *E. humile*, Desf., and figured in Barr. ic. 1011 as *Lycopsis angustifolia minor hispanica.* After Lamarck's time it became a source of perplexity and was confused by Salzmann, J. Gay, and Cosson with *E. Coincyanum*, mihi. Eventually Rouy rediscovered the species in 1879 at Jativa and at Hellin, the latter station being close to Tobarra, whence Lamarck had the type-specimen still to be seen in his herbarium. Rouy describes it fully in his Exc. Bot. ii. p. 16 (or in Bull. Soc. Bot. Fr. xxix. p. 123). It has been discussed at length by de Coincy in Morot's Journ. Bot. xiv. p. 106 and xvi. p. 215.

* A good many other Spanish specimens of "*pustulatum*" and "*creticum*" probably belong to *Coincyanum.* Collectors meeting with plants that look like possible *pustulatum* in Spain should make quite sure *in vivo* whether the filaments are perfectly glabrous, as in true *pustulatum*, Sibth. Porta & Rigo, It. iii. no. 142, seems to be a mixture, being an instance of the bad practice of those collectors in distributing specimens from more than one locality under the same number. This no. 142 is labelled "supra Calpe," which is on the coast between Valencia and Alicante, and also "Sierra de la Fuensanta," which is inland near Murcia.

On a specimen in hb. Cosson from S.W. Morocco leg. Mardochée, 1875, Rouy has pencilled "*australe.*" It is certainly not *australe* Lam., but I think it is *Coincyanum*, which very probably extends to Morocco. I had not time to search for it in Cosson's magnificent herbarium of North African plants now at the Paris Museum.

Lamarck's species is very near *E. humile*, Desf. (1791), which is not known from Spain, although Porta and Rigo distributed *angustifolium*, Lam., under that name. De Coincy separates these two specifically in Journ. Bot. xiv., but in his Enum. *Echium* Fl. Atl. in vol. xvi. *E. humile* and some other North African *Echia* are subordinated as varieties to *E. angustifolium*, Lam.

Unquestionably the name *angustifolium*, Lam., must give way to *angustifolium*, Mill., and Lamarck's species receive a new name. Now de Coincy identifies with *angustifolium* a certain *E. pycnanthum*, Pomel, which is the name substituted by that author in Nouv. Mat. Fl. Alg. fasc. 2, p. 276 (1876) * for his earlier *E. densiflorum*, described fully in Nouv. Mat. p. 92 (1874), but abandoned as a name owing to the existence of *E. densiflorum*, DC. Cat. Monsp. p. 108 (1813), a shrubby species introduced from "Teneriffe or Madeira," though apparently no longer found there.

E. pycnanthum, Pomel, is therefore the lawful name by which the *angustifolium* of Lamarck should be called, or, if reduced to a variety, *E. humile*, Desf., var. *pycnanthum* (Pomel), nov. comb. (=*E. angustifolium*, Lam., var. *pycnanthum*, Coincy).

Echium salmanticum.

The identity of this species can only be established by circumstantial evidence, as no authentic specimens are known and all that Lagasca says of his species in Nov. Gen. et Spec. p. 10 (1816) is "foliis radicalibus lanceolatis ; staminibus longissimis glabris, corollæ fauce subpervia. *E. Lusitanicum*, Linn. ? Hab. circa Salmanticam. Augusto floret."

The purport of this note is to make known J. Gay's description *ex vivo* of the plant cultivated in his day as *Echium salmanticum*, and to support the position taken up by Coutinho in Bol. Soc. Brot. xxi. p. 115 (1905), where *E. salmanticum* of Lagasca is identified with *E. polycaulon*, Boiss., Diagn. xi. p. 92 (1849), rather than with *E. lusitanicum*, L.=*E. italicum*, Brot.=*E. Broteri*, Samp. Boissier's species was described from a plant in herb. Pavon from the valley of Plasencia in Estremadura, and carefully distinguished by him from *E. lusitanicum*, L., as represented in Jussieu's herbarium. But practically this plant is only known from specimens collected by Bourgeau (no. 2467 of the year 1863) on the banks of the river Plasencia. These were distributed at first as *E. vulgare*, but the label was afterwards corrected by Reuter to *E. polycaulon*.

The arguments in favour of the identification of *E. salmanticum* with

* In the separate copies p. 296, but p. 40 where included in Bull. Soc. Sci. Alg. for 1876. There is no heading "*E. pycnanthum*," but a single line introducing the name forms the last of the paragraph describing *E. onosmoides*. Battandier had referred *E. pycnanthum* to *E. sericeum*, Vahl, a very different species, in Batt. et Trab., Fl. Alg. p. 609 (1888), but in Fl. Synopt. Alg. et Tun. p. 235 (1904), and in the suppl. to Fl. Alg. p. 67 (1910), de Coincy's opinion is accepted and *pycnanthum* is quoted as synonymous with *angustifolium*, Lam.

E. polycaulon are: (1) The relative proximity of Salamanca to Plasencia, whereas *lusitanicum* has only been found hitherto in northern Portugal and in Galicia in three localities in the frontier province of Orense (see Merino, Fl. de Galicia, ii. p. 155, 1906); (2) That a plant identical with Bourgeau's specimens of *polycaulon* from Plasencia existed under the name of *salmanticum* in several botanical gardens long before Boissier described his species, and in fact within 10 to 20 years of Lagasca's publication, thus raising a strong presumption that the seeds had come from Lagasca himself.

Of these early garden specimens of *salmanticum* identical with *polycaulon* the following have come to my knowledge: (1) Herb. Boiss. ex Hort. Genev., leg. Duby anno 1822; teste Buser ex Coutinho, l. c.; (2) Leipzig, anno 1835; teste Braun in litt. ined. ad J. Gay; (3) Hort. Neap. Novembri 1836; misit Tenore in Herb. Gay; (4) Hort. Carlsruh., unde semina misit Braun ad J. Gay anno 1839; (5) Hort. Paris. in Herb. Gay, anno 1843; (6) H. R. Neap. in herb. Ten.

The difference between *E. salmanticum*=*polycaulon* and *E. lusitanicum*, L. =*Broteri*, Samp., was recognised by J. Gay in his MS. notes in Herb. Kew before the publication of *polycaulon*. In addition to the specimen of *lusitanicum* received from A. de Jussieu, to which I refer in my notes on *E. lusitanicum* of Herb. Linn., Gay's herbarium contains two good examples of a plant grown in the Jardin des Plantes in 1843 from seed sent from Carlsruhe by A. Braun on Feb. 1, 1839, as *E. salmanticum*, Lag. Both are identical with Bourgeau's no. 2467 referred to above. Now *lusitanicum* and *polycaulon* resemble each other in their remarkable method of growth; Coutinho, Fl. Port. ii. p. 499, says they are perennial plants producing lateral stems below the rosette of basal leaves *. This had been described for *lusitanicum* by Brotero, Fl. Lus. i. p. 290, as follows: 'Caules quinque ad duodecim ex eadem radice, sub rosula foliorum radicalium, primum obliqui, dein incurvati, erectiusculi; folia radicalia in orbem prostrata, pedalia et longiora, ad medium biuncialia aut latiora, lanceolata." Gay observed the same character in the specimens he saw alive in the Jardin des Plantes, but not in the scraps of *lusitanicum* from the herbaria of Tournefort and Jussieu. He consequently thought that his cultivated plant must be identical with Brotero's *italicum*=*lusitanicum*, L., and suggested for it, but fortunately did not publish, the name *E. Broterianum*.

On Feb. 1, 1839, Braun writes from Carlsruhe to Gay: "Von *Echium salmanticum* schicke ich Samen; gehen sie Ihnen auf, so bekommen Sie die merkwürdigste Species aus diesem Genus, die von allen andern gänzlich abweicht durch ihren Wuchs. Als Sie meine *Echia* im Jahre 35 durchsahen, schrieben Sie an ein schlechtes Exemplar aus dem Leipziger Garten: 'Species

* Another perennial species from Spain and Portugal, *E. rosulatum*, Lange, has the same habit.

mihi obscura, *E. lusitanico*, L., similis sed corollis dimidio majoribus violaceisque non carneis certe diversa. Forte *E. plantagineum* parviflorum.'" This suggestion is of course impossible, and the rest of Braun's letter is devoted to distinguishing his *salmanticum* from *plantagineum*, with a rough sketch to show the dissimilar method of growth. The seeds germinated and on 25th June, 1843, Gay gathered in the Jardin de l'école de médecine de Paris one of the two specimens now in his herbarium, which at first he took to be "*E. lusitanicum*, L., et Lehm. = *E. italicum*, Brot.," annotating it "E. caulibus ex una radice pluribus, rosulæ centrali subjectis." But in a further note of July 2nd he modified the synonymy as follows: "*Echium Broterianum*, Gay = *E. italicum*, Brot., sed *Echium amplissimo folio lusitanicum*, Tourn. = *E. lusitanicum*, Poir., est planta longe alia. Longe alia videtur *E. caule simplici foliis caulinis lanceolatis*, etc., Royen, *E. lusitanicum*, Linn. et Lehm., cujus laciniæ calycinæ ex Lehmanno lanceolatæ sunt et acuminatæ, non vero (quæ Broterianæ) obtusiusculæ oblongæ vel ellipticæ." He seems to have thought there were three species where only two exist and erred in referring Brotero's *italicum* to the plant from the Carlsruhe seeds instead of to the other kind, *E. lusitanicum*.

On the same day, July 2nd, he gathered the other specimen now in his herbarium from the same seeds, and described it *ex vivo* as follows (it is the only description of this species from the living plant) :—

"*Echium salmanticum*, Lag. En pleine terre, ou il forme une énorme touffe de 2–3 pieds de haut. Ab *Echio lusitanico* herb. Jussiæani diversissimum. (1) Inflorescentia quasi racemosa non paniculata (spicis partialibus scilicet brevissimis non elongatis); (2) calyce quam corolla plus dimidio breviore, non corollam subæquante, phyllis ellipticis vel oblongis, non lanceolatis acutatis, margine et ad carinam ciliatis, cæterum glabris, non sparsim et longius setosis; (3) corolla ampliore multo imprimis latius aperta (limbo campanulato non cylindraceo-conico). Pili caulini uniformes, longi, patentissimi, firmuli, basi non bulbosi neque pube ulla breviore intermixta. Corolla violaceo-cærulea, adhuc clausa vinoso-rosea, 3½ lin. longa, ore maxime hiante 3 lin. lato, lobis limbi duobus superioribus paulo longioribus. Filamenta longe exserta, corollam plus duplo longa (*sic*). Caules ex una radice plurimi, spurii (revera rami radicales), rosulæ centrali (caule haud evoluto) subjecti!" Then on a much later ticket he added "*E. polycaulon*, Boiss.?"

The above account should be compared with Coutinho's description of *polycaulon* (*salmanticum*) in Bol. Soc. Brot. xxi. p. 111, and will be found to agree in essentials. There is a photograph of a herbarium specimen of *E. polycaulon* in Rouy's Illustr. Pl. Eur. Rar. tab. xli. It is strange that no one as yet should have taken the trouble to rediscover *E. salmanticum* in such an accessible locality as the neighbourhood of Salamanca. Both this plant and *E. lusitanicum* seem to have been lost from the gardens where they once were grown.

There is an *E. vulgare*, var. *salmanticum*, Coincy. in Morot's Journ. Bot. xiv. p. 304 (1900), which must not be confused with *E. salmanticum*, Lag. The specimen in de Coincy's herbarium, gathered by him at Salamanca on May 28th, 1892, on which his var. *salmanticum* is based, is very poor, hardly in flower, and I should have thought altogether too scanty to justify a new name. I rather doubt its being a form of *vulgare*.

II.

THE GENUS *ECHIUM* IN THE HERBARIA OF TOURNEFORT, JUSSIEU, AND LAMARCK.

These three famous herbaria, now in the Muséum d'Histoire Naturelle at Paris, are so important for the genus *Echium* that the following list of the specimens they contain may be useful. The first two have been examined and annotated by that minutely observant botanist, J. Gay. The third was not accessible to him, owing to its strange adventures. J. B. Monnet, chevalier de la Marck, ended his life in straightened circumstances in 1829. A few years before (1824) his herbarium had been bought, at the suggestion of Alexander von Humboldt, by J. A. C. Roeper, who took it with him to Bâle, and thence to Rostock, where he filled the chair of botany. From Roeper it was bought by the Grand Duke of Mecklenburg for the University of Rostock, and there remained till 1887, when it was offered for sale to provide funds of which the University was in need, and was purchased, with the help of the French government, for the Museum of Paris * :—

I. Herb. Tournefort.

no. 584 Sine nomine aut loco ; leaves only ; undeterminable.

„ 585 "*Echium majus et asperius flore albo*," labelled by Gay in 1834 "*E. pyrenaicum* Desf.," which it is not. The specimen consists of the upper part only of two stems, and is a wide-spreading form of *E. italicum*, L., which the French botanists often confuse with *E. pyrenaicum*.

„ 586 "*Echium majus et asperius flore dilute purpureo* Bot. Monsp.," labelled by Gay "*E. pyrenaicum* Desf.," which in this case is correct. It consists of two branches broken off a stem.

„ 587 no label of origin, but labelled by Gay "Verisimiliter *Ech. amplissimo folio lusitanicum* (specimen minus evolutum) = *Echium lusitanicum* Linn. Poir. etc." This is exactly the *lusitanicum* of herb. Linn. = *E. Broteri*, Sampaio.

* This information is collected from Bureau, "Sur l'entrée de l'herbier de Lamarck au Muséum d'Histoire naturelle," in Comptes Rendus, Ac. Sci. Par. 104, p. 187 (1887), and Bonnet, "L'herbier de Lamarck" in Morot's Journ. Bot. vi. p. 129 (1902).

no. 588 "*Echium vulgare paniculatum crispum,*" not labelled by Gay. A lusus or deformity of *E. vulgare*. The plant is in bud only.

" 589 "*Echium creticum angustifolium rubrum* C. B.," labelled by Gay "*E. creticum* α Poir. Dict." This is precisely *E. angustifolium*, Mill. = *E. elegans*, Lehm.

" 590 "*Echium sylvestre hirsutum, maculatum* C. Bauh." is unmistakably *E. rubrum*, Jacq.

" 591 "*Echium maritimum Insularum Stœchadum, flore maximo cæruleo,*" labelled by Gay "Je crois que cette forme rentre dans le *grandiflorum* Desf., qui selon moi, constitue une espèce bien distincte du *plantagineum*." He is right; it is the narrow-leaved form of *grandiflorum* that is found here and there in Dept. Var.

" 592 "*Echii* genus in maritimis insulæ Porquerolles," root-leaves only; undeterminable.

" 593 no name but "Fouqué," labelled by Gay "*Echium orientale folio oblongo molli et cinericeo*, Tourn. Cor. 6? *E. pustulatum* Ten.! in herb. mus. Par. non Sibth." Then Chaubard notes "*Echium vulgare pilis adpressis* Viv. Fl. Agen. Il n'est pas d'orient, mais de la France méridionale." The specimen is one of the forms that replace typical *vulgare* in southern France, sometimes determined by French botanists as *pustulatum*, sometimes as *tuberculatum*, though not the *tuberculatum*, Hoffmg. et Link, nor the true *pustulatum* of Sibthorp. See my notes on Sibthorp's herbarium.

" 594 "*Echium Cupani,*" labelled by Gay "*Echium calycinum* Viv.," which it is.

" 595 no name, but labelled by Gay "*Echium vulgare* L.," to which I assent.

" 596 no name, but labelled by Gay "*Echium plantagineum* (hortense fol. floralibus solito majoribus, flore paulo minore)." I assent.

" 597 no name; no label by Gay; a branched plant in fruiting state, apparently of the group that represent *vulgare* in the south, but I cannot venture on a close determination.

" 598 no name and no label by Gay; it is *E. flavum*, Desf.

" 599 no name; an unknown hand has suggested in pencil *E. arenarium*, Guss., which is right.

" 600 "*Echium Ægyptiæ, flore magno suave rubente,*" labelled by Gay "*Echium Rauwolfii* Delil.," which is right.

Tournefort's herbarium contains no specimen of his *E. orientale, verbasci folio, flore maximo campanulato.*

II. Herb. Jussieu.

no. 6601 *Echium* unnamed "ex hort. Bagatelle 1788." Only the upper half of a plant which is obviously *E. lusitanicum* herb. Linn. = *Broteri*, Samp.

" 6603 contains three sheets with no original name, all labelled by Gay "*pyrenaicum*," but only two belong to that species, the third being *italicum*, L.

" 6604 labelled by Gay "*E. italicum* L., Willd., Lehm et aliorum nonnull.," is either true *italicum*, L., or *glomeratum*, Poir. For lack of time I could not examine carefully.

" 6605 two sheets:

(1) "*E. amplissimo folio lusitanicum. Ech. lusitanicum folio cubitali* T. hb. Isnardi."

(2) "*E. amplissimo folio lusitanicum*" ex herb. D. Charles." Both specimems are undoubtedly the *lusitanicum* of herb. Linn.

" 6606 "no. 48 *Ech. undulatum* Pourr. Gallice, envoyé par M. Pourret 1802," labelled by Gay "forte *E. lusitanicum* L.," which it is, being identical with no. 6605.

" 6607 two pieces:

(1) "*E. rubrum*" is rightly corrected by Gay to *E. vulgare*.

(2) "*E. creticum angustifolium rubrum* ex hb. D. Charles" is *vulgare corollis roseis*.

" 6611 "*Echium Insularum Stœchadum*" is rightly labelled by Gay "*E. plantagineum*," for it is not the plant so-called in Tournefort's herbarium no. 591.

" 6612 two sheets, ex herb. Isnard and ex herb. Charles, both named "*Echium creticum latifolium rubrum*," but both are *E. plantagineum* and have been so labelled by Gay.

" 6613 "*Echium orientale*" is *plantagineum* as labelled by Gay. This must be the specimen alluded to by Poiret, Dict. Encyc. viii. p. 673, where he says that he has seen Tournefort's type of *E. orientale* in hb. Jussieu.

" 6614 "*Echium* ex hisp."	do.	do.
" 6615 "*Echium* ex hort. R. Paris"	do.	do.
" 6616 *sine nomine*,	do.	do.
" 6617 "*Echium bonariense*"	do.	do.
" 6618 *sine nomine*, a scrap	do.	do.

" 6619 two sheets:

(1) "*E. australe* Lam. ex hort. reg. Paris, Desf." marked "bene" by Gay.

(2) *sine nomine aut loco*. Both are precisely the *creticum* of herb. Linn.

no. 6620 *sine nomine* "ex h. r. Paris," labelled by Gay "*E. grandiflorum* Desf.?" This also is identical with *E. creticum* of hb. Linn.

„ 6621 "*E. foliis angustis et villosis* T. R. H. 136 ex hb. Isnardi," no note by Gay. There are four sheets of a much branched plant. This synonym is referred by Jussieu in Barr. p. 16 to *Anchusa angustis villosis fol. hisp.* Barr. Ic. 577, which is *Echium hispanicum* Asso, Mant. Stirp. Arag. p. 162 (1781). As I had not seen Pau's specimens of Asso's *Echium* at the time I was in Paris, I could not recognise it in these sheets, and dare not express an opinion from memory.

„ 6622 two sheets:

(1) "*E. hispanicum verrucosum annuum angustifolium* ex hb. P. et hb. Charles" is identical with no. 6621.

(2) "*E. rosmarinifolium* (? *Roris-marini folio*) T. H. 136 ex hb. Charles," may also be *hispanicum*, Asso, or the Spanish plant commonly called *pustulatum*. I cannot say, for the reason mentioned above. Both (1) and (2) are labelled by Gay "*E. tuberculatum* Hfg. & Lk.?" which they are not.

„ 6630 six sheets:

(1) "*E. creticum angustifolium rubrum* ex hb. Isnardi," labelled by Gay "*E. creticum* α Poir. ex hb. Desf.," is identical with hb. Tournefort no. 589. It is *E. angustifolium*, Mill. =*E. elegans*, Lehm. I have examined the specimens in Desfontaines's herbarium at Florence referred to by Gay. There are three, on which Gay has noted "Ex hisce tribus speciminibus suum *E. creticum* elaboravit Poiret in Dict. viii. p. 670, quorum duo Syriaca, meum ined. *E. Tournefortii*, tertium Ægyptiacum *E. prostratum* Delil. Æg. sistit." Nos. 1 and 2 came from Labillardière, who collected in Syria, but they are *sine loco*. They are *E. angustifolium*, Mill.=*E. elegans*, Lehm. No. 3, sent from Egypt by Delile himself, is typical *E. sericeum*, Vahl, which is Delile's *prostratum*.

(2) *sine loco*; my MS. abbreviated note is illegible.

(3) "misit D. Thunberg e Tripoli" is apparently also *angustifolium*.

(4) *sine loco*, labelled by Gay "Je ne puis distinguer cette plante du *E. plantagineum*." This is certainly not *angustifolium*, but is either *plantagineum* or *maritimum*. I did not examine it minutely.

(5) and (6) are both *angustifolium*=*elegans*.

I cannot now explain the lacunæ in the numbers between 6607 and 6611 and between 6622 and 6630. I may have accidentally missed some sheets.

III. Herb. Lamarck.

1. "*Echium vulgare*" sine loco. It is.
2. "*Echium rubro flore montis aurei*," presumably Mont D'Or. It is *vulgare fl. roseo.*
3. "*Echium plantagineum* Vahl" is *E. plantagineum*, L., a specimen with fine large radical leaves.
4. "*Echium elongatum* Lam. an *Echium majus et asperius fl. albo*? Ses fleurs sont d'un blanc un-peu incarnat., les corolles sont courtes." An unknown later hand has added "*Echium glomeratum* Poir.," which it is not, being precisely *E. italicum*, L. (as already noted by de Coincy) =*altissimum*, Jacq.
5. "*Echium fruticosum* L." is *Lobostemon fruticosus*, Buek.
6. "*Echium argenteum* Berg. 40 et Lam. Ill., Pluk. Tab. 341. f. 8" is *Lobostemon argenteus*, Buek, the plant figured by Jacquin Hort. Schœnb. i. p. 34, as *E. fruticosum*, but not the plant named *E. argenteum* in the Linnean herbarium (see my paper on the *Echia* of Linnæus, *infra*, p. 396).
7. "*Echium capitatum*" is *Lobostemon capitatus*, Buek.
8. "*Echium capitatum* var. *β*" is *Lobostemon sphærocephalus*, Buek.
9. "*Echium spicatum*" is *Lobostemon spicatus*, Buek.
10. "*Echium strictum* Lam. Ill." is *E. strictum*, L. fil.
11. "*Echium falcatum* Lam. Ill." with a label in later writing "*Lophost. glaber* Buek," which apart from the mis-spelling, is probably right.
12. "*Echium candicans* L. suppl." is that species.
13. "*Echium italicum* . . . . (illegible) Pernegul. *Echium asperrimum* Lam. Ill." is precisely *E. pyramidale*, Lap., with whose type-specimens I have compared it, and therefore is *E. pyrenaicum*, Desf.
14. "*Echium angustifolium* Lam. Ill. *E. hispanicum* Tobarra = Barr. Ic. 1011." This is the type of Lamarck's species, which Poiret wrongly identified with *E. angustifolium*, Mill. Salzmann, J. Gay, and Cosson misinterpreted this name, applying it to a very different species, *E. Coincyanum*, mihi. But Rouy re-discovered the true plant in 1879 not far from Tobarra, and later collectors have distributed it as *E. humile*, Desf. But de Coincy, who discusses it fully in Morot's Journ. Bot. xiv. p. 106, and xvi. p. 215, points out that it is not true *humile*. The name *angustifolium* suits admirably, but is unavailable owing to the priority of Miller's *angustifolium*. It must therefore be called *E. pycnanthum*, Pomel, Nouv. Mat. Fl. Atl. fasc. 2, p. 40 (but p. 296 in some copies, where the paging is consecutive with the author's earlier publication), where the name is substituted for *E. densiflorum*, Pomel, owing to the existence of the earlier *E. densiflorum*, DC. Barr. Ic. 1011, *Lycopsis angustifolia minor hispanica*,

certainly represents the plant of Lamarck, who, however, was wrong in quoting for it *E. hispanicum*, for which see note on no. 6621 of Herb. Jussieu.

15. "*Echium australe* Lam. illustr.," with a later label in an unknown hand "*Echium lusitanicum* ?," a ridiculous suggestion that may be dismissed. This, again, is an important type. It is absolutely identical with the specimen of *E. creticum* in herb. Linn. No doubt a garden plant, originally derived from *E. grandiflorum*, Desf., but not from the narrow-leaved, upright form of that species found in Dept. Var. The flowers are badly dried and look smaller than they really are. There are no ripe nucules, so that de Coincy's description of them in Morot, Journ. Bot. xiv. p. 327, where he mixes up Lamarck's *australe* with *E. Coincyanum*, mihi, cannot have been derived from Lamarck's type.
16. "*Echium creticum* Lam. ill.," labelled by a later hand "*Echium creticum?*" Three examples: one "ex D. Sonnerat," the others *sine loco*. They are all *E. plantagineum*, L., to which Lamarck's *creticum* has long ago been referred.
17. "Petit rameau détaché d'une sommité fleurie d'un *Echium* frutiqueux des Canaries," labelled by a later hand "*Echium aculeatum* Poiret," which it may well be.

III.

THE *ECHIA* OF SIBTHORP'S HERBARIUM.

The specimens in Sibthorp's herbarium, now at Oxford, were originally tied up in bundles corresponding to Sibthorp's different journeys and the districts from which they came. But the individual specimens are without any indication of locality or determination by Sibthorp himself, the only writing on the sheets being in Smith's hand, except in the case of plants from the island of Zante, which were not collected by Sibthorp, but purchased from a druggist of the island, who has written on some of them the local Greek name.

Smith tells us, in Rees's Cyclopædia *sub voce* Sibthorp, that the plan of the 'Prodromus' was drawn out by Dr. Sibthorp, but nothing of the 'Flora Græca' except the figures was prepared, nor any botanical descriptions. "The final determination of the species," he says, "the distinction of such as were new, and all critical remarks have fallen to the lot of the editor." He has not always been very happy in these determinations and remarks. In the genus *Echium* alone he has fallen into two grave errors. But we must remember that he had not the copious material collected by later travellers, which makes it so easy for us to criticise his work.

Smith has not attempted to determine all the specimens. Only seven species of *Echium* are enumerated in Fl. Gr. Prodr. i. pp. 124–126 (1806), and of the fourteen examples of that genus in the herbarium only seven have been named by Smith. Nine of the fourteen bear a printed label with "J. Sibthorp, M.D.," indicating that they were actually collected by him. Three others are marked, apparently in a clerk's hand, "Herb. Sibthorp. South of Europe. Qy.," and the remaining two are from the Zante collection mentioned above. From a copy of the 'Prodromus' in the possession of the Linnean Society, it appears that at one time authentic Sibthorpian specimens of his *E. hispidum* and *E. creticum*, presented by Dr. Daubeny, existed in the Society's general South European herbarium. Unfortunately, these were sold by auction on November 10th, 1863, being comprised in lot 82 with Welwitsch's Portuguese collection and Dr. Prior's east Mediterranean plants. The lot only fetched 34 shillings, but the purchaser's name is not known. The loss is peculiarly unlucky, as those two species are the very ones about which Smith went wrong. He appears to have taken the names of the three new species of the 'Flora Græca' (*E. pustulatum*, *E. hispidum*, and *E. diffusum*) from some list of Bauer's figures which he found among Sibthorp's papers, but which does not seem to have been preserved. Sundry rough lists exist among Sibthorp's MSS., but they contain none of the above names. A list "intended to form the outline of the 'Flora Græca'" only includes three *Echia*, viz., no. 164, *E. italicum*, no. 165, *E. vulgare*, and no. 166, *E. creticum*, without localities; and a list of Thracian plants mentions "*E. violaceum in campis Thraciæ*" and "*E. creticum in campis circa Byzantium.*" There is nothing in the lists to connect these names with any particular specimens.

It seems that Bauer did not draw—or, at any rate, did not complete—the figures of the 'Flora Græca' from live plants. His originals exist at Oxford. They have been most faithfully reproduced by Sowerby in the published plates. There are also many sheets of Bauer's pencil-sketches of the different parts of the organs of the plants, perhaps done in the field, but at any rate from freshly-gathered specimens. Portions of several species belonging to different genera are found on the same sheet. These sketches are marked all over with numbers indicating the precise tints to be afterwards applied in the coloured pictures. The tints must have been very numerous, as the numbers run to upwards of 200.

I have to thank Mr. Druce for much of the above information and for the facilities afforded for the examination of the specimens enumerated and discussed below.

(I.) Echium vulgare, L., labelled "Herb. Sibth. South of Europe. Qy.," and not named by Smith. It is a large specimen with the upper half of the stem cut off, but I have little doubt that it is *E. vulgare*, which is quoted in

Prodr. i. p. 125 for Byzantium and Laconia. The latter station seems to me very doubtful for typical *vulgare*, which is not found on the shores of the Mediterranean.

(II.) ECHIUM PUSTULATUM, labelled by Smith "*Ech. pustulatum* Sibth. list of figures." This is certainly the plant represented in Fl. Gr. tab. 180, although in a more advanced state than the figure. In Prodr., *l. c.*, and Fl. Gr. ii. p. 68, Sibthorp is said to have found this species "in Sicilia tantum.' Nevertheless, it agrees perfectly with the example collected by him in the kingdom of Naples, now in Herb. Banks, but wrongly referred by Smith to *E. hispidum*, whose expression "in agro Neapolitano" must, I think, be understood to mean "in the kingdom of Naples," not "in the vicinity of Naples," where that precise form is not found, though it occurs in southern Calabria as well as in Sicily. Among some rough notes of Smith's at Oxford I have come across "*Echium hispidum* Sibth. from Naples; stem very bristly; flowers smallish, blue," which is sufficient to exclude the real *hispidum*. It is possible that Sibthorp himself may at some time have confused *pustulatum* with the very different Greek plant figured as *hispidum*. Modern specimens, which entirely agree with both the above Sibthorp specimens, are :—

1. Todaro, Fl. Sic. no. 931, from Messina, a locality also quoted by Gussone, Fl. Sic. Syn. i. p. 232, for *E. pustulatum*.
2. Thomas in Hb. Gay at Kew, from Calabria, anno 1816.
3. Arcangeli in Hb. Kew, from Cape Spartivento in Calabria.
4. Tenore in Hb. Kew, from southern Italy, without precise locality.

I am unable to see any real distinction between the above and two well-known exsiccata from Nicolosi on the slopes of Etna, viz. :—

5. Strobl, Fl. Ætn., 24. vi. 1872.
6. Lojacono, Pl. It. Select. no. 72.

Nevertheless, these were referred to by their collectors to a form that Gussone, *l. c.*, and Lojacono, Fl. Sic. iv. 2, p. 76, supposed to be distinguishable from *pustulatum*, and wrongly referred to *E. tuberculatum*, Hoffmg. et Link, quoting Nicolosi as a locality. True *E. tuberculatum*, Hoffmg. et Link, as interpreted by de Coincy in Morot, Journ. Bot. xiv. p. 303 (1900), and by Coutinho, Fl. de Portugal, p. 500 (1913), and represented by the following specimens, does not exist in any part of Italy * :—

* Alph. de Candolle remarks in Prodr. x. p. 19, under *E. tuberculatum*, "omnia ex verbis cl. auct. Nemo specimina authentica vidit et omnes de hac specie disposuerunt. Pater diversas plantas ex Italia, Gallia et Hispania sub hoc nomine in herb. consociavit, sed communio dissocianda." This judicious observation has been overlooked by many French and Italian authors, *e. g.*, by Loret, Glanes d'un Botaniste, in Bull. Soc. Bot. Fr. vi. p. 406 (1859), who, though he properly declines to identify the so-called *pustulatum* of southern France with Sibthorp's *pustulatum*, unfortunately refers it to *tuberculatum*, Hoffmg. & Link.

7. Schultz, Herb. Norm. no. 1429; S. José prope Conimbricam, Maio 1882, leg. Moller (in Herb. Bailey at Manchester).
8. Fl. Lus. Exs. Hort. Bot. Conimbr. no. 110; Coimbra, Quinta das Maias, Aprili 1886, leg. Moller, but named "*pustulatum*" (Herb. Mus. Brit.).
9. J. Daveau, Herb. Lusit. 1878; Penna de Pau, environs de Lisbonne (Herb. Kew).
10. Burchell, Cat. in Lusit. lect. no. 565, as *E. vulgare* (Herb. Kew).

The common *Echium* that replaces *E. vulgare* in Istria and the greater part of continental Italy is by no means identical with Sibthorp's type of *pustulatum*, and is quite different from the Portuguese *tuberculatum*, though usually known by one or other of these names. It seems intermediate between *vulgare* and *pustulatum*, and may well be known as *E. vulgare* var. *grandiflorum*, Bert., under which name it has been admirably described by Bertoloni, Fl. It. ii. pp. 348, 350. It is the *pustulatum* of Koch and of many Italian authors, but the *tuberculatum* of Gussone's Neapolitan herbarium. J. Gay noticed the difference between true *pustulatum* of Sibthorp and this form, which he proposed to call *E. Tenoreanum*. His MS. notes attached to the Calabrian specimen of *pustulatum* in his herbarium (no. 2 above) are interesting. "*E. pustulatum*, Fl. Gr. Prodr. planta sicula. Fl. G. t. 180 optima . . . . Sibthorpii icon. in Fl. Graec. meum calabricum specimen optime refert; rami floriferi longiusculi et omnes partes hispidissimæ; sed tota planta nimium viridis, quod forte uni pictori tribuendum. Unum quod Parisiis vidi siculum *E. pustulati* specimen, in hb. Fontanesii exstat, in monte Ætna a D. Schouw lectum. Huic in sesquipedalem longitudinem porrecto et simplicissimo spiculæ sunt 11, brevissimæ vix unciales, extrorsum arcuatæ, unde habitu certe differt. Hoc vero non nisi ab ætate juniore pendere videtur. Convenit vero cum

His treatment of the subject loses much of its value owing to his conception of *pustulatum* being based on a Bourgeau specimen from southern Spain, which is not Sibthorp's species, and has been referred by de Coincy to *E. pycnanthum* (*angustifolium*, Lam., non Mill.), but his remarks on the French plant are interesting: "Quoique l'*E. pustulatum* de Toulouse et de la Flore de France ait un facies un peu différent de celui de l'*E. vulgare* ordinaire, et qui suffit le plus souvent pour empêcher de le confondre avec lui, on éprouve néanmoins, lorsqu'on étudie chaque organe, une sorte d'impossibilité d'y reconnaître des caractères stables et vraiment spécifiques. Celui notamment qui est relatif à la forme de la panicule est tellement variable, et par suite si peu distinctif, qu'il me parait sans valeur." He does not seem to have been aware that the nucules of these southern plants are not those of typical *vulgare*. Rouy, on the other hand, Fl. Fr. x. p. 317, being well aware that the French plant is not the true Portuguese *tuberculatum*, refers the former back to *pustulatum* treated as a subspecies of *vulgare*: but that he had no clear idea of *pustulatum* appears from his quoting both Bourgeau, no. 1314, and Todaro, no. 931, as representing it, though these two exsiccata belong to different species.

meo. *Echium pustulatum* Ten.* in herb. Mus. Paris (in arvis siccis circa Neapolim a Tenorio lectum) alia planta est, *Echio vulgari* longe affinior, foliorum pube cum hoc vulgari conveniens, diversa satis in bracteis, foliorum margine et costa dorsali rigidioribus lucidis, strigulis brevissimis rigidis adpressis bractearum dorsum occupantibus, etc."

This intermediate var. *grandiflorum* is represented by the following, among many other, examples :—

11. Portici al Granatello (near Naples), from Tenore as *E. vulgare* in Hb. Kew.
12. Ibidem, from Gussone as *E. tuberculatum* in Hb. Kew.
13. M. Gargano, from Tenore as *E. vulgare* in Hb. Kew.
14. "In collibus aridis totius Dalmatiæ," Unio It. 1829 as *E. pustulatum* in Hb. Kew.
15. Veglia (Dalmatia), leg. Bauer as *E. pustulatum* in Hb. Kew.
16. Zara (Dalmatia), leg. A. Braun as *E. pustulatum* in Hb. Kew.

The last three obviously represent Koch's conception of *E. pustulatum*. Like typical *vulgare* this form occasionally occurs with pink corollas, when it has been mistaken by Italian botanists—*e.g.*, Bertoloni, Fl. It. ii. p. 347—for *E. angustifolium*, Mill. (*hispidum* Sibth.), which is not Italian †.

Although I have looked through—somewhat hurriedly—all the French specimens of *Echium* in the Paris Museum and those of M. Rouy ‡, I have found none among them that are undoubtedly identical with Sibthorp's *pustulatum*. Most so-named Spanish examples are referable either to *E. Coincyanum*, mihi = *E. creticum*, Willk. et auctt. hisp., non Linn., or to *E. hispanicum*, Asso § = *Anchusa angustis villosis foliis hispanica*, Barr. Ic. 577, but I cannot speak positively as to others.

The systematic value of *E. pustulatum* as represented by Sibthorp's type, and its relation to the other forms referred to, remains doubtful. What is clear is that the *vulgare* of northern and central Europe is replaced in the Mediterranean, not by one equivalent form, but by sundry "little species," differing from each other as much as from typical *vulgare*, and that these have hitherto been very superficially studied. Herbarium specimens are

* Tenore usually sent out this form from the vicinity of Naples as *vulgare*, sometimes as *tuberculatum*, occasionally, as in the specimen here referred to, as *pustulatum*. True *pustulatum* he sometimes sent out under that name but sometimes as *tuberculatum*, so that his specimens, for which a precise locality is rarely indicated, are valueless for nomenclature. I have seen Schouw's Etna plant in hb. Desfontaines, now at Florence; it is like no. 5 above, and undistinguishable from Sibthorp's specimen.

† See my observations on *E. Sibthorpii* in Nuov. Giorn. Bot. It. xxv. p. 136 (1918).

‡ Rouy's fine herbarium is now the property of Prince Roland Bonaparte, who most generously welcomes those who wish to study his magnificent collections.

§ Mant. Stirp. Indig. Arag. p. 162 (1781). A copy of this rare work is in the library at Kew. Specimens distributed by Pau are in the Bailey herbarium at the Manchester Museum.

usually very unsatisfactory in this genus. They should be collected with the complete radical leaves before flowering, then in flower, and again with fully developed fruiting spikes. Both true *pustulatum* and *vulgare* var. *grandiflorum* differ from our English *vulgare* in a more branching habit, which however is not developed in weaklings; in corollas normally larger, of a different blue, which shows purple streaks or a slight purple tinge; in stamens not so far exserted *; and particularly in the nutlets, which, instead of being merely rugose with inconspicuous, if any, tubercles, are remarkably papilloso-tuberculate. This last character has been rather cavalierly treated by de Coincy, *op. cit.* p. 303, but if it can be established as constant it would be decisive in favour of a specific separation from *vulgare* of the forms in which it occurs. But it requires further observation on a sufficient number of fresh specimens in different regions.

There is one other point to notice. De Coincy, at pp. 303 and 323, distinguishes *vulgare* and *pustulatum*, treated as a variety of *vulgare*, as having glabrous filaments, whilst in *tuberculatum*, Hoffmg. et Link, "at least one of the three posterior filaments is hairy, and usually all three." Though hairy filaments are very important in some other species, notably in *grandiflorum*, Desf., they afford so feeble a character in *tuberculatum* (which is quite distinguishable on other grounds) that it has been deliberately ignored by Prof. Coutinho. The hairs are very few and very weak, and extremely difficult to see in any herbarium specimen—indeed, I very much doubt the constancy of their presence. Yet they are not always entirely absent, as they are in all forms of *vulgare* and in all specimens of *pustulatum* that I have examined. I have refrained from dissecting the few remaining corollas of Sibthorp's type, but as far as can be seen they are glabrous, and so they are in Todaro's identical plant. Nevertheless, in the detail of tab. 180 at least two of the filaments are shown as hairy, and I have verified that they were so drawn by Bauer in his original sketch. The kind of hairs figured, sparse and slender, suggests that Bauer must have really seen them. They are not the kind of pubescence that an artist would be likely to introduce apart from actual observation. I am unable to explain this matter further.

(III.) Echium angustifolium, Mill., labelled by Smith "*Echium hispidum* list of figs. Naples. Sibth. in H. Banks." This is precisely *E. hispidum* of Fl. Gr. tab. 181. The synonymy is *E. angustifolium*, Mill. Gard. Dict. (1768), non Lam. = *E. hispidum*, Prodr. Fl. Gr. p. 125 (1806) = *E. elegans*, Lehm. Asperif. p. 459 (1818) = *E. Sibthorpii*, R. et S. Syst. iv. p. 26 (1819) = *E. sericeum* var. *hispidum*, Boiss. Or. iv. p. 207 (1879).

* The phrases "included" and "exserted" have been used ambiguously of the stamens of the irregular corollas of this genus. By "included," I understand shorter than the lower lip of the corolla; "exserted" should, I think, mean exceeding the upper lip. Stamens that exceed the lower, but fall short of the upper, lip may fairly be said to equal the corolla and be called sub-exserted.

Lehmann created the name *elegans* and Roem. & Sch. that of *Sibthorpii* (before he had seen Lehmann's publication of the preceding year) for Sibthorp's species, owing to the existence of Thunberg's *hispidum* of 1794 (Prodr. Pl. Cap. p. 33), the much earlier *hispidum*, Burm. fil. Fl. Cap. Prodr. p. 5 (1768), being reduced at the same time by Lehmann to a synonym of *E. capitatum*, L. Both these are Cape Lobostemons, but in any case the priority belongs to Miller's name, the identity of which with Sibthorp's *E. hispidum* I have maintained in my notes on the *Echia* of Miller's 'Gardener's Dictionary.'

This species, which is the *E. creticum* II. of Clusius and the *E. creticum angustifolium rubrum* of C. Bauhin and of Tournefort, is plentiful in Crete and in many parts of Greece. By Linnæus it has been mixed up with a totally different species under the confused name of *E. creticum*. Smith was misled into supposing that Sibthorp had obtained the plant "in agro Neapolitano" by his false determination of the specimen in Herb. Banks, now at the British Museum, which, as stated above, is not *hispidum* but *pustulatum*. It is possible that Sibthorp himself at some period may have confused this South Italian *pustulatum* with the Greek species figured as *E. hispidum*. A similar confusion had been made by Miller (see my note on his *E. angustifolium*).

(IV.) Echium parviflorum, Moench, labelled by Smith "*Echium creticum*."

(V.) Echium parviflorum, Moench, labelled by Smith in ink "*Echium creticum*" and in pencil "Sibth. at vix H[erb].L[inn]. perhaps from Naples." Both IV. and V. are *parviflorum*=*calycinum*, Viv., no. V. being the usual seaside plant, and no. IV. the stronger form that develops in richer soil = var. *erectum*, DC. Smith's pencil note shows that the error of taking this plant for *E. creticum*, L., was not due to him but to Sibthorp. I cannot account for the false colour attributed to the corollas in Prodr. p. 126, where Smith calls them "rubro-violacei," and so they are represented in tab. 183, whereas in most cases they are pale blue. The false identification in De Candolle's 'Prodromus,' x. p. 22, of *creticum*, Fl. Gr., with *creticum*, L., is explained by the observation in a footnote "plantam Linnæi et ic. Fl. Gr. non vidit pater nec ego."

(VI.) Echium plantagineum, L., labelled by Smith "*Echium plantagineum* H. L." It is quite typical; the corollas have dried partly blue, partly purple.

(VII.) Echium plantagineum, L., from Zante, not named by Smith, but "no. 45 *βουδόγλωσσον*." In this the corollas have dried blue.

(VIII.) Echium plantagineum, L., also from Zante, not named by Smith, but labelled "234 *βούγλωσσον*." In this case the corollas have dried pale

pinkish purple as shown in Fl. Gr. tab. 179. *E. plantagineum* frequently tends to this colour in the Ionian islands. In the Atlantic islands, to judge by the numerous examples in Herb. Kew, it seems usually to be a rich purplish blue.

(IX.) Echium plantagineum, L. Three small pieces on one sheet, on which is written in a clerk's hand "Herb. Sibthorp. South of Europe Qy?" These have not been named by Smith.

(X.) Echium italicum, L., labelled by Smith "*E. italicum* H. L." A small piece in fruit, very hirsute.

(XI.) Echium italicum, L., not named by Smith. On the sheet is written "Herb. Sibthorp. South of Europe Qy?" Both X. and XI. are true *E. italicum*, not *E. pyrenaicum*, which does not seem to grow in Greece.

(XII.) Echium arenarium, Guss., not named by Smith. It shows the typical small dark blue corollas with style as well as stamens included. This species is plentifully represented in modern herbaria from Crete and from Attica. Halácsy, Consp. Fl. Gr. ii. p. 340, wrongly identifies *E. diffusum*, Sibth. et Sm., with *E. arenarium*.

(XIII.) Echium diffusum, Sibth. et Sm., labelled by Smith "*Echium diffusum* Fl. Gr. tab. 182." The specimen is in fruit.

(XIV.) Echium diffusum, Sibth. et Sm., not named by Smith, but with the printed label "J. Sibthorp M.D.," showing it to have been collected by Sibthorp. It is identical with no. XIII. These two specimens differ *toto cœlo* from *E. arenarium* in their reddish corollas with conspicuously exserted style and stamens as long as the upper lobes. The fruiting calyces also differ from those of *arenarium*. It is true that in Fl. Gr. ii. p. 69, *E. diffusum* is described "staminibus corolla brevioribus" and tab. 182 shows them about as long as the corolla. But in these specimens they are longer than they are drawn by Bauer and certainly not shorter than the corolla. The colouring of that figure and the words in the text, "flores punicei, precedenti (sc. *E. hispido*) similes," exclude *E. arenarium*. In fact, *E. diffusum* is precisely *E. sericeum*, Halácsy, *loc. cit.* p. 339, non Vahl, quoted by that author for the plant from the sandy shore at Canea, more correctly referred by DC., Prodr. x. p. 23, to *E. diffusum*. Identical specimens from the isle of Naxos may be seen in Herb. Gay at Kew, ticketed "*E. diffusum* Smith. In Naxo insula ann. 1829 ; Despréaux sine nomine in herb. Deless. Frustula haecce speciminis multicaulis dedit Guillemin. Schedulæ Despréauxianæ nomen *E. arenarium* Guss. propria manu addidit Gussone, sed falso, ut mihi videtur. Species valde affinis *E. setoso*, Vahlii,

an satis diversa? Diversissima a *setoso* Delile seu *arenario* Guss.," and again in Heldreich's exsiccata from that island under the name of *E. arenarium β. Sieberi*. This var. *Sieberi* was so named by De Candolle, Prodr. x. p. 21, and is based on an Egyptian specimen collected at the Pyramids by Sieber, which I have not seen. The Egyptian exsiccata most like Sibthorp's plant and those from Naxos are a prostrate form of *E. sericeum*, Vahl, from Ramleh, with subexsert stamens, which differ from Sibthorp's *diffusum* in possessing the adpressed pubescence of typical *sericeum*.

Boissier, Fl. Or. iv. p. 207, treats *E. diffusum* as a variety of *sericeum*, quoting it from Cos and Cyprus as well as from Crete and Naxos. This is right from his point of view, as he also treats *E. angustifolium*, Mill., as var. *elegans* of *E. sericeum*. But if *angustifolium* and *sericeum* are kept up as separate species and *diffusum* submerged, it is a problem to which of the former *diffusum* should be referred as a prostrate variety. The chief difference between those two species is in the indumentum—adpressed and rather silky in *sericeum*, but patent and hispid in *angustifolium*. That of *diffusum* seems intermediate, but to my eyes nearer to that of *angustifolium*, where it would also be preferable to place *diffusum* on geographical grounds. It seems best to retain *diffusum* as a species until much more copious material is available.

The synonymy therefore is *E. diffusum*, Sibth. et Sm., Prodr. i. p. 125 =*E. sericeum*, Halácsy non Vahl =*E. sericeum*, Vahl, var. *diffusum*, Boiss. =*E. arenarium* var. *Sieberi*, Heldr., exsicc. non DC.

IV.

THE LINNEAN SPECIES OF *ECHIUM*.

The *Echia* of Linnæus and his son comprise six South African species now referred to the genus *Lobostemon*; one from Asia Minor transferred by Boissier to his monotypic genus *Megacaryon*; three shrubby species of *Echium* from the Atlantic islands, and nine European herbaceous species. It is only with the last that I propose to deal fully, as the Atlantic species and the *Megacaryon* offer no difficulty, and I am not sufficiently acquainted with the South African flora to say much about the *Lobostemons*, though two of these, nos. 1 and 6, raise problems of interest.

Not all these nineteen species are represented in the Herbarium, which, however, contains three not mentioned in the Linnæan writings, viz.: *Lobostemon montanus*, Buek, *Echium rubrum*, Jacq.. and a small *Echium* from Spain which I cannot determine with any confidence.

I shall first enumerate the species, then the specimens, then offer some general remarks, and finally discuss the European species. As the sheets in the herbarium are not numbered, they are referred to by letters of the

alphabet, as the use of numbers might lead to confusion should the sheets themselves be numbered at some future time:—

(I.) Lobostemon*.

1. *Echium argenteum*, L. Mant., p. 202, non *Lobostemon argenteus*, Buek in Linnæa, x. p. 133. This is specimen O in the herbarium, labelled *E. argenteum*. It has been examined by Mr. N. E. Brown, who confirms that it is not the *L. argenteus* of Buek, but a species not otherwise known, which he has described and named *Lobostemon magnisepalum* in a paper read before the Linnean Society on 6 February, 1919, which will appear later in this Journal. The herbarium contains no specimen corresponding to *E. argenteus*, Buek.
2. *Echium capitatum*, L. Mant., p. 42=*Lobostemon capitatus*, Buek, *l. c.* p. 143. Specimen Q.
3. *Echium fruticosum*, L. Sp. Pl. (1753) p. 139=*Lobostemon fruticosus*, Buek, *l. c.* p. 134. Specimens R, S, T.
4. *Echium lævigatum*, L. Sp. Pl. (1762) p. 199=*Lobostemon lævigatus*, Buek, *l. c.* p. 139. Specimens U, V.
5. *Echium spicatus*, L. fil., Suppl. p. 132=*Lobostemon spicatus*, Buek, *l. c.* p. 145. Specimen W.
6. *Echium*, unnamed=*Lobostemon montanus*, Buek, *l. c.* p. 152, on the authority of Mr. N. E. Brown. Specimen P.

(II.) Megacaryon.

The herbarium contains no specimen of *Echium orientale*, Sp. Pl. p. 139, and it is practically certain that Linnæus never saw the plant in any form. Its identity depends entirely on the synonym quoted from Tournefort, "*Echium orientale, verbasci folio, flore maximo campanulato*," and that author's account of it in his 'Voyage au Levant,' ii. p. 248 (1717), or iii. p. 83, in the English translation of 1741. It is first mentioned by Linnæus in Hort. Cliff. p. 43, "*Echium caule ramoso, foliis caulinis ovatis, floribus solitariis ex alis.* Tourn. Cor. 6; itin. 3, p. 94. Crescit in Oriente." The diagnosis in Sp. Pl. is a mere transcript of this with the word "lateralibus" substituted for "ex alis." Tournefort found his plant at Grezi on the road from Trebizond toward Armenia. His description and the locality make it certain that it is the species for which Boissier created his monotypic genus

* I have not included in the *Lobostemon* list an *Echium glabrum*, Linn., Epist. ed. van Hall, p. 27 (1830), where that name is given in a letter to J. Burman, of Oct. 4th, 1758, for a plant received from him. The diagnosis runs, "*E. glabrum*, caule lævi, foliis lanceolatis nudis, margine carina apiceque scabris," with synonyms of Pluk., Old., and Herm. On the strength of these synonyms, Richter, Cod. Linn. p. 156, identifies this plant with *E. lævigatum*, published two years after this letter was written. *E. glabrum*, Vahl, and *E. glabrum*, Thunb., are of course much earlier than this *E. glabrum*, Linn., of 1830.

Megacaryon in Pl. Or. Nov. Decas i. p. 7 (Feb. 1875), based on Bourgeau's specimen from Macka. Boissier does not there allude to Linnæus or Tournefort, but in Fl. Or. iv., published later in the same year, he altered the name from *Megacaryon armenum* to *M. orientale*, quoting *Echium orientale*, L., and Tournefort's synonym.

The synonymy therefore is *Megacaryon orientale,* Boiss. Or. iv. p. 204 (1875) = *M. armenum*, Boiss. Pl. Or. Nov. Dec. i. p. 7 (1875, Feb.) = *Onosma megalospermum*, Boiss. in Bourg. exsicc. = *Echium orientale,* L. Sp. Pl. p. 140 (1753) = *E. grandiflorum*, Salisb. Prodr. p. 115 (1796), non Desf.

Boissier says "ex unica corolla exsiccata in specimine fructifero fausto caso superstite florem descripsi," but since then fine specimens in flower and fruit have been collected by Sintenis, It. Orient. 1892, nos. 4159 and 4859, from two places in Paphlagonia. These may be seen in Herb. Kew and in Mus. Brit. Poiret, Dict. Encyc. viii. p. 673, says that he has seen Tournefort's type in Herb. Juss. He no doubt was alluding to specimen no. 6613, which, although labelled *orientale*, is nothing but *E. plantagineum.* There is no example of Tournefort's species in his own herbarium. That Linnæus never saw a specimen is certain, not only from his giving no diagnosis of his own and merely quoting Tournefort, but also from an MS. note in his interleaved copy of Sp. Fl. ed. 2, where he quotes for *E. orientale* Tournefort's figure, and also Trew, Pl. Rar. tab. 1, published in 1768. Trew's figure, which seems to represent *E. grandiflorum*, Desf., is so utterly unlike *Megacaryon orientale*, that no one who had ever seen an example of that striking plant could have connected this figure with it.

(III.) Echium. (A) Atlantic shrubby species.

1. *Echium candicans*, L. fil. Suppl. p. 131. Specimen A, which is actually the type referred to by Linn. fil.
2. *Echium giganteum*, L. fil. ibidem. No specimen.
3. *Echium strictum*, L. fil. ibidem. No specimen.

(IV.) Echium. (B) European herbaceous species.

1. *Echium creticum*, L. Sp. Pl. (1753) p. 139. Specimen N.
2. *Echium italicum*, L. ibidem. Specimen H.
3. *Echium lusitanicum*, L. ibidem. Specimen M.
4. *Echium plantagineum*, L. Mant. p. 202. Specimen C.
5. *Echium pyrenaicum*, Desf. (L. Mant. p. 334). Specimen I.
6. *Echium rubrum*, Jacq. Not mentioned anywhere by Linnæus, but represented in the herbarium by the three unnamed specimens J, K, L.
7. *Echium violaceum*, L. Mant. p. 42. Specimen F.
8. *Echium vulgare*, L. Sp. Pl. (1753) p. 139. Specimen B.
9. *Echium* —— ? Specimen G.

The Linnean herbarium contains two covers marked Echium. In these there are 23 sheets, of which only thirteen bear specific names in the handwriting of Linnæus; two more are in that of his son; but eight are unnamed. In two instances there are two sheets pinned together, although bearing quite different plants. As there is no evidence that they were so pinned by Linnæus himself, this raises no presumption that he supposed the pinned specimens to belong to the same species.

Of the 23 specimens one is a minute example of *Lithospermum apulum*; nine are *Lobostemons* from South Africa; one is *Echium candicans* from Madeira, and the remaining twelve are European species.

For the sake of clearness, all writing on the sheets is here quoted in italics between inverted commas, and followed by the letters L., L. fil., or J. E. S.; the last standing for Sir J. E. Smith, all whose notes are written in pencil.

List of Specimens.

A. Inscript. "*candicans. Madera Mason,*" L. fil., and a tergo "*Echium plantagineum thyrsiflorum in rupis*" (sic) "*altioribus. Mason ex litteris,*" L. fil. A fine specimen.

B. Inscript. "*3. vulgare,*" L. It is sine loco.

C. Inscript. "*plantaginifolium H. U.,*" L., indicating that it is a cultivated specimen from Hort. Ups.

D. Inscript. "*A. 39,*" L., and "*Was pinned to vulgare. E. orientale H. B.?*" J. E. S. Sine loco, but probably received from Alstroemer.

E. Inscript. "*L. 152,*" L. Sine nomine aut loco, but the inscription indicates a plant received from Loefling, and therefore from Spain or Portugal. Below this sheet is pinned sheet G.

F. Inscript. "*E. violaceum H. U.,*" L. Cultivated specimen from Hort. Ups.

G. Inscript. "*152 a,*" L., and a tergo "*Echium montanum parvum, flore magno. In montibus Espartal. Lo . . .,*" L. The last three letters of the collector's name are undecipherable, but he was probably Loefling. This sheet is pinned below sheet E.

H. Inscript. "*2 italicum,*" L. Sine loco. Below this sheet is pinned sheet J.

I. Inscript. "*pyrenaicum H. U.,*" L., et a tergo "*flores purpurei,*" L. A cultivated specimen from Hort. Ups.

J. Inscript. "*ε,*" L., signifying that it came from Gerber, who collected in South Russia. This sheet is pinned below sheet H.

K. No inscription.

L. No inscription.

M. Inscript. "*Echium lusitanicum folio amplissimo Tourn.*" in the handwriting of Jan Burman, then "*lusitanicum*" in that of Linn. fil., followed by "?" J. E. S.

N. Inscript. "*creticum 4,*" L. and a tergo "*Echium creticum,*" L.

O. Inscript. "*Echium argenteum 145,*" L. The number is doubtless that of the specimen in the list of those sent by Tulbagh to Upsala about the year 1767, which was published as a Supplement to the 'Proceedings of the Linnean Society' for 1917–1918. In that list No. 145 is said to come from the Swartberg, but is there referred by Linnæus to *Echium fruticosum.*

P. Inscript. "*Sp. 86,*" L., indicating that it came from Sparrman, who collected in South Africa.

Q. Inscript. "*capitatum,*" L.

R. Inscript. "*Echium fruticosum,*" L.

S. Inscript. "*fruticosum 98,*" L., which again suggests Sparrman.

T. Inscript. "*fruticosum,*" L.

U. Inscript. "*lævigatum,*" L., and "*H. B. et Willdenow,*" J. E. S.: H. B. meaning Herb. Banks.

V. Inscript. "*lævigatum,*" L.

W. Inscript. "*Echium spicatum,*" L. fil.

Z. No inscription by Linnæus, but "*Lithosp. apulum?*" J. E. S. Smith's determination seems correct.

(I.) **ECHIUM CRETICUM** of Linnæus is an inextricable compound of two distinct species :—

1. *E. creticum angustifolium rubrum*, C. B. P. = *E. angustifolium*, Mill.* (1768), non Lam. = *E. hispidum*, Sibth. & Sm. (1806) = *E. elegans*, Lehm. (1818) = *E. Sibthorpii*, Roem. et Sch. (1819).

2. *E. creticum latifolium rubrum*, C. B. P. = *E. creticum*, herb. Linn. = *E. australe*, Lam., non Coincy, a garden form certainly not derived from any native of Crete or the eastern Mediterranean, and not specifically distinguishable from *E. grandiflorum*, Desf.

The herbarium specimen is identical with that of *E. australe* in hb. Lamarck, which I have examined. I have discussed Lamarck's species in a preceding paper, which should be read with the present observations. It only differs from *E. grandiflorum*, Desf., in having corollas about one-third smaller. Its identity with the species of Desfontaines has already been claimed by Moris, who visited the Linnean herbarium and remarks in Fl. Sard. iii. p. 128, "Herbar! specimen e planta luxuriante." De Coincy declined to grapple with the problem of the identity of *E. creticum*, L. In May 1918, I received seeds of *grandiflorum* from Prof. Battandier of Algiers, which by the end of July had produced plants in my garden at

* The justification of the revival of Miller's name, which has been overlooked, will be found in my paper on the *Echia* of Miller's 'Gardener's Dictionary,' *infra*, p. 437.

Selham, Sussex, identical with the Linnean specimen. The later sowing shows diffuse lower branches lying on the ground, which explain the "caule procumbente" of the misquotation (see below) in Sp. Pl. p. 139. The corollas vary in the same plant from 28 to 35 mm., but hardly attain the largest Algerian size.

The herbarium specimen of *E. creticum* consists of two pieces on the same sheet, possibly from the same plant. The larger is the upper part, about 35 cm. long, of a plant in flower with a branched stem. The six branches vary from 11 to 15 cm. in length. They are therefore approximately equal, giving an appearance of a diffuse habit. In this piece the lower calyces are as much as 2 cm. apart and barely 1 cm. long. They are exceeded by the bracts, the lower of which are sub-foliaceous, but the middle and upper exactly match those similarly placed in *E. grandiflorum*, Desf., being broadly ovate at the base and acuminate, with the two sides conspicuously unequal. The smaller piece is a single branch in fruit, 26 cm. long, but not yet fully extended as the uppermost corollas are still in flower. This has fruiting calyces only 1 cm. apart, but 1–1½ cm. long with unequal laciniæ.

The corollas are very oblique, shaped as in *E. grandiflorum*, about 2·5 cm. long *in sicco*, and less than 1 cm. wide at the throat, softly pubescent outside without long hairs on the veins; the lower lobes shortly and closely ciliate, but the upper without ciliæ. The stamens are shorter than the upper lobes and are best described as subexsert; they are very hairy. The colour of the corolla is now a dark dingy purple (quite unlike that of the specimen of *violaceum*, which has dried blue), and has obviously been red in the living plant. The leaves vary from ovate to oval, being much broader (8–10 cm. by 3–4 cm.) than in any of the specimens of *grandiflorum* from south-eastern France, but only a little broader than in some of those from the Spanish border and from Algeria. The lateral veins are conspicuous, as shown in Desfontaines's figure of *grandiflorum*. Their indumentum is dimorphous, with few long bristles arising from inconspicuous tubercles. It is, in fact, that of *grandiflorum*, but scantier, which I attribute to the effect of cultivation. As in that species the dried plant is the colour of tobacco.

To sum up: this plant appears to be a garden form of *grandiflorum* with a more widely branching habit and wider leaves than normal. Though identical in shape, pubescence, and colour, the corollas are not so large as in fine specimens of *grandiflorum*. Desfontaines's figure (Fl. Atl. tab. 46) shows a less widely branching plant with narrower stem-leaves than the Linnean specimen of *creticum*, which is well represented by the figure in Sweet's Brit. Flower Garden, tab. 101 (April 1st, 1825), under the name of *E. australe*. This was a garden plant grown from seeds received from Germany under that name. Sweet's description is well worth consulting.

Specimens corresponding with that of Linnæus are not uncommon in the old herbaria. They all are undoubtedly taken from garden plants.

The question now arises whether the name *E. creticum*, L., should be used either for *E. australe*, Lam. = *E. grandiflorum*, Desf., or for *E. angustifolium*, Mill. = *E. elegans*, Lehm., or whether it should not rather be entirely discarded as a *nomen confusum*. The following considerations will, I think, establish that it must be discarded:—

It will be best to begin with the history of the name *creticum*, which first appears in Clusius, Hist. ii. p. 164 (1601). He describes two species as *E. creticum* I. and *E. creticum* II., both from garden plants. His descriptions are not in themselves such as to allow of certainty, but it is pretty clear that No. I. is the *creticum* of herb. Linn. and No. II. is *E. angustifolium*, Mill. He observes "bina porro alia *Echii* genera, Cretico semine, quod mittebam, nata, creverunt Joanni ab Hogelande, anno MDXCIII. . . . accipiebam autem semina, ex quibus hæ plantæ natæ, non *Echii* appellatione sed *Anchusæ*, cujus semen e Creta allatum esset." The use of the mood in "esset" indicates that though the seeds were supposed to have come from Crete, this was uncertain. This little turn of the Latin did not escape Linnæus, who says in Hort. Cliff. of No. II. "crescit forte in Creta." The Cretan origin may be accepted for No. II. but not for No. I., as no *Echium* resembling the Linnean specimen or those of the other old herbaria has ever been found in the island, *E. creticum*, Fl. Gr. being notoriously *E. parviflorum*, Moench.

The next mention of the name is by C. Bauhin, 'Phytopinax,' p. 489 (1596), where, distinguishing *E. rubrum creticum* from *E. vulgare*, he says "minus est, sed ramosius, paucioribus floribus; eleganter rubent; tota planta Lycopsin alteram anglicam Lobel icon. p. 579 plurimum refert." The allusion to Lobel's figure, which represents *E. italicum* or *E. pyrenaicum* (see my notes on Miller's *Echia*), shows that Bauhin meant Clusius No. II. = *E. angustifolium*, Mill. Afterwards, in the 'Pinax' of 1623, p. 254, he enumerated without diagnosis two species, *E. creticum latifolium rubrum* and *E. creticum angustifolium rubrum*. These are the names which constantly recur in later authors and obviously correspond to Clusius's *creticum* I. and *creticum* II.

It is uncertain, and indeed immaterial, to which of these two should be referred the *Echium Candiæ flore pulchre rubente* of J. Bauhin, Hist. iii. p. 589 (1651), distinguished from *E. vulgare* as "magis ramosa, flores forma similes, nempe hiantes, sed colore diverso pulchro, scilicet rubente." Though I think it more probably corresponds to *creticum* I.

Linnæus first speaks of *E. creticum*, in Hort. Cliff. p. 43 (1737), as follows: "*Echium caule simplici, foliis caulinis linearibus, floribus spicatis ex alis. E. creticum angustifolium rubrum* Bauh. Pin. 254; Boerh. lugdb. i. p. 194. *E. creticum* 2 Clus. Hist. 2, p. 145. Crescit forte in Creta, unde Clusius semina habuit." The Hort. Cliff. plant is therefore identical with *E. angusti-*

folium, Mill., to the exclusion of *E. creticum latifolium*, which explains why the specimen of the latter in Herb. Hort. Cliff. bears no name.

We next find in Hort. Ups. p. 35 (1748) "*Echium calycibus fructiferis distantibus* [1]; *E. caule simplici f. caulinis linearibus* etc. Hort. Cliff. 43 [2]; *E. creticum angustifolium et latifolium rubrum* Bauh. Pin. 254 [3]; *E. rubro flore* Raj. hist. 499 [4]; Hab. in Syria unde semina habui [5]; Differt (sc. ab. *E. italico*, specie præcedenti) caule magis ramoso, magis folioso, foliis magis ovatis, corollis maximis rubris [6]." So here confusion begins. To analyse the six statements I have numbered: [1] is his new diagnosis which he afterwards repeats in Sp. Pl. It is very characteristic of the herbarium specimen, of some examples of *E. plantagineum*, and also of *E. grandiflorum*, but is inapplicable to *E. angustifolium*. [2] Can only apply to *E. angustifolium*. [3] Mixes up Bauhin's two very distinct species. [4] Is quoted in error, as this synonym belongs to *E. rubrum*, Jacq. See my notes on that species. [5] Seeds of *E. angustifolium* may well have come from Syria, where that kind is plentiful, as well as in Greece and Crete, but neither *angustifolium* nor any other Syrian plant could have given rise to the herbarium specimen *. [6] The whole of this observation only agrees with the herbarium specimen, admitting of Clusius No. I. The "corollis maximis rubris" is very important. It is consistent with only two species, viz. *E. amœnum*, Fisch. & Mey., and *E. australe*, Lam., var. *macranthum*, Coutinho = *E. grandiflorum*, Desf. But *E. amœnum* is out of the question, so that *grandiflorum* is the only alternative. Both "maximis" and "rubris" are fatal to *E. creticum*, Fl. Gr., which notoriously is *E. parviflorum*, Moench, and "maximis" excludes *E. angustifolium*.

We now come to *E. creticum*, Sp. Pl. p. 139, where there is no fresh diagnosis but only the quotation of three synonyms, that from Hort. Ups. †, that from Hort. Cliff., and the *E. creticum latifolium* et *angustifolium*, C. B. P. Also "*Habitat in Creta*" and the obs. "*stamina non longiora labio breviore corollæ*." The note about the stamens agrees fairly well with the herbarium and with *E. grandiflorum*, but excludes *E. angustifolium*.

Some further light (?) is thrown by two incidental remarks in Mant. ii. p. 202, where Linnæus says of *E. plantagineum* "corollæ violaceæ, non cæruleæ *E. vulgaris* nec breviores *E. cretici*" and "bracteæ longitudine

* It is possible that Linnæus may have received the seeds of his herbarium specimen from his frequent correspondent Gouan, who might easily have obtained *E. australe* from Southern France and forwarded it under the name of *creticum* without mentioning its origin. In the British Museum there is a specimen like that of Linnæus from Hort. Gouan, unnamed by him, but labelled by Solander first *creticum* and subsequently *lusitanicum*!!

† Linnæus here strangely misquotes his own Hort. Ups. by altering *fructiferis* to *fructescentibus* and adding the words *caule procumbente*, which are not found in Hort. Ups.

calycis non subulatæ *E. vulgaris* nec calyce longiores *E. cretici*." The remark about the bracts agrees with the herbarium and excludes *E. angustifolium*. The difficulty is the phrase "nec breviores *E. cretici*." There must be some slip of the pen or of the printer. The most natural interpretation of the words is "not shortish as those of *E. creticum*" *. But that would be in direct conflict with fact and with the "*corollis maximis*" of Hort. Ups. We should have to suppose that his thoughts had shifted to *E. creticum angustifolium*, for its corollas are smaller than those of *E. vulgare* and much smaller than in *E. plantagineum*. But this supposition does not seem compatible with the immediately following remark about the bracts. The only alternative is to suppose either that *cretici* is a misprint for *cretico*, or that the word *illis* has dropped out after *breviores*, and to interpret "not shorter than *E. creticum*" or "not shorter than those of *E. creticum*." This would make good sense and fit the facts, but it would put a great strain on the words as they stand.

Lastly, in Mant. p. 334 (1771), Linnæus added "*E. creticum*; *corolla saturate rubræ, tubo calycibus breviore. Filamenta apice parum pilosa*." The hairy filaments exclude *angustifolium* in which they are glabrous, but are most characteristic of *australe* and of its large-flowered form. The hairs can be seen in the herbarium specimen, of which also the corollas look as if they had been "saturate rubræ," judging by their present dull dark reddish appearance. The phrase "tubo calycibus breviore," however, presents a slight difficulty, as it does not seem compatible with "corollis maximis." It may be meant only to indicate that the calyx-segments are remarkably long, as indeed they are in *grandiflorum* and in the herbarium specimen †.

Can we be surprised that, after Linnæus had so hopelessly mixed up two species which his predecessors had kept distinct, his followers should have found themselves perplexed? It would be sheer waste of paper to go through all the ways in which the name *creticum* has been used subsequently; de Coincy calls it "l'inévitable *creticum* que tous les anciens botanistes ne manquaient pas d'appliquer à tous les *Echium* qu'ils ne savaient pas nommer." It will be enough to say that the *creticum* of Poiret ‡, of Lehmann, and of

* Is it possible that these words may have led Sibthorp, and consequently Smith, to apply the name *creticum* to *E. parviflorum*, Moench?

† The way in which authors speak of the corolla tube being longer or shorter than that of the calyx in this genus is very vague, as they do not define the point at which they consider the tube of the corolla to end and the limb to begin. As a rule, there is no marked separation.

‡ Poiret, Dict. Encyc. viii. p. 671, makes two varieties of *E. creticum*, referable respectively to *E. angustifolium*, Mill., and to *E. sericeum*, Vahl, wrongly quoting (together with sundry other misapplied synonyms) *E. creticum latifolium rubrum*, Tourn., for the first, and *E. creticum angustifolium rubrum*, Tourn., for the second, with the observation, "La première recueillie en Syrie par M. de Labillardière, est bien celle de Tournefort, comparée avec son herbier, et la seconde celle de Forskal. V. s. in herb. Desfont." This statement is criticised as follows by Gay in a note in his herbarium: "Poiret a décrit son *creticum* sur deux échantillons conservés dans l'herbier Desfontaines et rapportés de Syrie par Labillar-

de Candolle's 'Prodromus' are inextricable muddles of plants and of synonyms.

The conclusion then is :—

(1) The Linnean specimen and other similar garden forms should be called *E. australe*, Lam., not *E. creticum*.

(2) *E. creticum*, L., is a confusion of two totally distinct species, and a confusion so intricate that the name cannot be used for either of them, or indeed for any species, but must be rejected as a *nomen confusum*.

The following old specimens, all undoubtedly garden plants, are the same as that of the Linnean Herbarium. All except the last two are at the British Museum :—

1. From Hort. Cliff., unnamed.
2. Herb. Miller, labelled in Miller's hand "*E. calycibus fructescentibus* etc. H. U. 35 ; *E. creticum latifolium rubrum*" and by Solander "*E. creticum.*" This is the smaller piece on a sheet, the larger piece on which is *E. plantagineum*, although the names seem intended to apply to both pieces.
3. Chelsea garden, no. 1367 of 1749, labelled "*E. creticum angustifolium rubrum* C. B. P.," "*angustifolium*" being obviously a slip of the pen for "*latifolium.*"
4. Herb. Leche ; two pieces, one labelled originally "*lusitanicum*" but subsequently "*creticum* L. H. S." (Linnæi Hortus Siccus), the other labelled "*creticum* Sp. Pl. 139."
5. Hort. Gouan, unnamed by him but labelled by Solander first "*creticum*" and subsequently "*lusitanicum.*"
6. Herb. Pallas, labelled originally "*violaceum*" and then by Solander also "*violaceum.*" There are two pieces on the sheet, one being *creticum*, Herb. Linn. but the other *plantagineum*.

7 and 8. Herb. Pallas, both labelled originally "*creticum,*" then by Solander first "*creticum*" but subsequently "*australe.*"

9. Herb. Pallas, labelled originally "*E. creticum hortense,*" then by Solander first "*creticum*" and subsequently "*australe.*" There are two pieces on the sheet, one being *creticum*, Herb. Linn., but the other is *E. amœnum*, Fisch. & Mey.

dière. Il y rapporte l'*E. cret. latif. rubr.* de Tournefort, et en lisant sa descr. on croirait qu'il a vu cette plante dans l'herbier de Tournefort. Il est pourtant certain qu'elle n'y est point. A sa place on trouve l'*E. cret. angustif. rubr.* Tourn. que Poiret rapporte mal à sa var. *β*. et qui est identique avec les échantillons de Labillardière." Gay is right, but in herb. Desf., besides the Labillardière specimens from Syria, which are just *E. angustifolium*, Mill., there is one of Delile's from Egypt, which is typical *E. sericeum*, Vahl (see my notes on herb. Jussieu, no. 6630). Now typical *sericeum* has even narrower leaves than *angustifolium*, which is the probable explanation of how Poiret came to misapply the two Bauhin phrases adopted by Tournefort.

10. Herb. Smith "ex Herb. Davall. 1802."
11. In the Fielding Herbarium at Oxford, an old example *sine loco* marked "*creticum*."

These specimens reveal how vague were Solander's notions of his great master's species of *Echium*. There are sundry other old specimens at the British Museum marked "*creticum*" which are neither *creticum* of the herbarium nor *angustifolium*, Mill. For instance :—

a. Herb. Sloane, vol. 198, p. 50, from Petiver's 'Plantæ Rayanæ' marked "*E. cret. latif. rubrum*" is *E. plantagineum*.
b. Herb. Sloane, vol. 306, p. 154, from Herb. Uvedale, similarly labelled, is *E. lusitanicum* (*E. Broteri*).
c. Hort. Cliff., labelled "*E. creticum latifolium rubrum*" and "*creticum*" is *E. plantagineum*.
d. Hort. Cliff., labelled "*E. creticum angustifolium rubrum*" (though identical with the preceding specimen) is also *plantagineum*.

(II.) **ECHIUM ITALICUM** and **ECHIUM PYRENAICUM** are best dealt with together, though I consider them to be quite distinct species, *italicum* being identical with *E. altissimum*, Jacq., but *E. pyrenaicum* with *E. pyramidale*, Lap.

The diagnosis of *italicum*, without the name, first appears in Hort. Ups. p. 35 (1748) as *E. corollis vix calycem excedentibus, margine villosis*, with three synonyms: (1) *E. majus et asperius flore albo*, Bauh. pin. 254. Raj. hist. 498 ; (2) *Echii altera species*, Dod. pempt. 631; and (3) *Lycopsis* Bauh. pin. 255. There follows the obs. "Differt ab *Echio vulgari*, Fl. Suec. 158, foliis pallidioribus, angustioribus, lævioribus ; racemis minoribus, corollis cinereis s. cœruleo-exalbidis vix calyce longioribus," also "Habitat in Anglia, Italia. Hospitatur in frigidariis, biennis." The diagnosis and obs. therefore tell us that (*a*) the corollas are small, but exaggerate their smallness, (*b*) that they are villous on the margin, (*c*) that they are pale, grey or bluish white. (*a*) and (*b*) admit of any of the forms that have claimed to be *italicum* of Linnæus, but (*c*) definitely excludes *pyrenaicum*, in which the corollas are pink, with the beautifully coloured stamens so carefully described in the Mantissa and by Lapeyrouse. And it is to be remembered that in both cases Linnæus was acquainted with the living plant, so that we are not thrown back on the synonyms to so great an extent as in some cases.

The habitat Italia would cover both *altissimum* and *pyrenaicum*, though the latter only occurs there within a limited area. Anglia is impossible for either*. To the statement *biennis* I shall refer hereafter.

To come to the synonyms : (1) C. Bauhin's name is undoubtedly the well-

* In quoting Anglia, Linnæus only followed a mistake of the old English botanists, which I have traced and fully discussed in my paper on the *Echia* of Miller's 'Gardener's Dictionary.'

known whitish-flowered plant figured by J. Bauhin, Hist. Pl. iii. p. 586 (1651), that agrees with Linnæus's "corollis cinereis etc." ; and of which an extra luxuriant individual is figured by Jacquin as *altissimum*. What Ray says of this synonym is all important, for he had himself observed the plant "in agro Salernitano et Romano, inque Etruria et Gallia Narbonensi." The first three regions are precisely those districts of Italy where *italicum* = *altissimum* is extremely plentiful, but where *pyrenaicum* does not exist. The former is most abundant in the Roman Campagna. The traveller can easily recognise it from the window of his railway-carriage all the way from Bologna to far beyond Naples. If he travels on to Taranto it will accompany him from Salerno across the watershed of Potenza and far down the valley of the Basiento. But he will never see it in the plains of Apulia, where it is replaced by *pyrenaicum*, Ray's next species, called by him "*Echium majus et asperius flore dilute purpureo* Botan. Monsp.," both *italicum* and *pyrenaicum* being found, the latter more commonly, in the Montpellier district.

(2) Dodoens's account of his *Echii altera species* * is far from clear; but as his figure is a mere reproductien of that of Lobel's *Lycopsis altera anglica*, which first appeared in Stirp. Hist. p. 312 (1576) and is repeated in his Ic. Stirp. p. 579, it really coincides with the next synonym (*c*), and is referable to *E. pyrenaicum*.

(3) The *Lycopsis* of C. Bauhin is, as I have explained fully in my paper on the *Echia* of Miller's 'Gardener's Dictionary,' a muddle of *E. plantagineum* with *E. pyrenaicum* as represented by the above-mentioned figure of Lobel. Linnæus was obviously unaware that *plantagineum* was mixed up in this synonym when he subsequently quoted *Lycopsis* for his *italicum* β=*pyrenaicum*.

Echium italicum as a name starts in Sp. Pl. p. 139 (1753), with the diagnosis of Hort. Ups. repeated and only one synonym, *E. majus et asperius*, Cam. epit. 728, which of course is the same as the identical Bauhin phrase, but a β makes its appearance, without any diagnosis or comment, to receive the *Lycopsis* synonym. Then in the second edition, p. 200, a new diagnosis is substituted, *E. caule erecto piloso, spicis hirsutis, corollis subæqualibus, staminibus longissimis*, the synonyms being his own diagnosis of Hort. Ups. and those of C. Bauhin and Camerarius, with *Lycopsis* again referred to var. β, of which now we obtain some account, to which I will return when speaking of *E. pyrenaicum*. Linnæus's later works give us no further information about his typical *italicum*, though they bring fresh matter for var. β *pyrenaicum* †.

Unquestionably the plant that, according to the usual and legitimate practice, must bear the Linnean specific name is the first form described, especially seeing that a different name for var. β appears in the Mantissa and in the herbarium for the specimen corresponding to that variety. The only specimen in the herbarium marked *italicum* by Linnæus is precisely the

* P. 620 in ed. of 1583, but p. 631 in that of 1616.

† The reference to Hudson's Fl. Angl. in Sp. Pl. ed. 2, p. 1678, mentioned below, only adds confusion, not information.

Echium majus et asperius flore albo so common in Italy. Its identity with the *E. altissimum* of Jacquin is proved by comparison with an authentic specimen of the latter in the British Museum "herb. Jacq." and by numerous modern exsiccata, of which I have selected those in my list A as being absolutely identical with the Linnean specimen.

The Linnean specimen of *italicum* is an upper part only, without root or lower leaves; the narrow inflorescence measures about 30 by 5 cm.; it is in flower, so the cincinni are not yet fully unfurled. Corollas and filaments now show a dirty cream-colour. In similar specimens the fully developed radical leaves are very long and narrow, 30 by 3 cm., even 30 by 2 cm.; the inflorescence in the flowering state averages 45 by 5–6 cm., even reaching 55 by 6 cm., but broadening after the cincinni are fully unfurled to 45 by 8–12 cm.

Jacquin's figure, Austr. tab. 16 (in App.), shows a more than usually luxuriant plant. In his admirable description, v. p. 35 (1778), he remarks "corolla perpetuo alba; filamenta alba; antheræ cum virore flavescunt," which agrees with Italian examples. It may be asked how Jacquin came to create an *E. altissimum* if it is identical with Linnæus's *italicum*. The reason is simply that from Linnæus's brief diagnosis he could not know that the species said to live in Italy and England was his own Hungarian plant. He makes no attempt to distinguish *altissimum* from *italicum*, which he does not so much as name. Subsequent authors, especially the French, followed by Kerner in Oest. Bot. Zeit. xxiii. p. 164 (1873), and in Fl. Exs. Austr. Hung. nos. 3174 and 3175, assuming, without sufficient thought, that Jacquin's and Linnæus's names must indicate different plants, had to find another to play the part of *italicum* and unfortunately pitched upon *pyrenaicum* as being the true *italicum*, regardless of Linnæus's own descriptions and without dreaming of consulting his herbarium.

The following attempt to describe is based on Italian specimens, but it must be remembered that in the case of so large a plant, herbarium specimens are either incomplete or are undersized individuals, which do not always exhibit characteristic habit.

ECHIUM ITALICUM; unicaule, sive in exempl. luxuriantibus, pluricaule *. Caules in typo 40–100 cm. alti, simplices, non nisi ramulis singulis ex axillis præditi (in var. *Biebersteinii* subramosi propter ramulos inferiores ipsos cincinnis pluribus brevissimis dissitis munitos).

* This character is claimed specially for *E. albereanum*, Naud. & Debeaux (=*E. flavum*, Lap., non Desf.), by Roumeguère in Soc. Agr. Pyr. Or. xxii. p. 163, note, "la plante est multitige, le type, on le sait, est constamment unitige," but the writer meant *pyramidale*, Lap., not true *italicum*, by "le type"; Debeaux remarks, *op. cit.* xxiii. p. 176, "cette espèce se distingue à première vue de l'*E. pyramidale* par ses tiges élevées, nombreuses dès la base et non unitiges." Admirable to distinguish it from *pyrenaicum*=*pyramidale*, but the character is common to all forms of true *italicum*, and often occurs in strong plants of *E. vulgare*.

Ramuli, infimis exceptis, simplices, usque ad 1–2 cm. nudi, ibique robustiores in cincinnos geminos æquales bifurcantur, debiliores cincinno unico terminantur.

Cincinni initio brevissimi, valde scorpioidei, deflorati erecti vel erecto-patentes usque ad 8–10 cm. (15–20 cm. in var. *Biebersteinii*) producuntur. Inflorescentia in typo spiciformis, sub anthesi c. 45 × 5 cm., post anthesin c. 45 × 8–12 cm.; in var. *Biebersteinii* conica, propter axem centralem ramos inferiores, quamvis elongatos, fere duplo excedentem. Flores, ut in genere, distichi, subunilaterales, confertissimi, bracteis anguste lanceolatis calycem (laciniis inclusis) c. 6–7 mm. longum æquantibus.

Corollæ parvæ subregulares, c. 12 mm. longæ, tubo fere recto, extus pilosæ, pilis paucis longioribus strigosis intermixtis, sordide albæ vel subcæruleo-albescentes; filamentis concoloribus. Stamina longissime exserta sæpius corollam fere duplo superantia.

Folia radicalia angusta, longa vel longissima; evoluta 30 × 2–3 cm.; caulina lanceolata, superiora 4–8 cm. longa, cincinnos floriferos longe excedentia *.

Indumentum e pilis strigosis, confertissimis (præcipue in var *siculo*), inæqualibus sed homomorphis, in sicco lutescentibus †.

But the name *italicum* L., though it must exclude *pyrenaicum*, will cover the broader conical form which occurs frequently in the Balkans and in Greece, and in Southern France seems to be more usually met with than *altissimum*, from which, however, it certainly cannot be specifically separated, having the same system of ramification with the very predominant central axis, and the tendency, even in a greater degree, to produce subsidiary stems from the base. It also has the long, narrow, hairy, hardly tuberculate root-leaves, the small pale yellowish or bluish-white corollas, showing cream-colour like the pale filaments in *sicco*, and the yellowish indumentum. The outline of the inflorescence is conical rather than pyramidal, the height being at least double that of the base; it measures about 40 cm. by 20–25 cm., and shows a similar ratio in smaller examples. This outline is due to a larger number of the lower axillary branches being prolonged, and themselves bearing rather widely spaced short branchlets, each consisting of single or twin cincinni. I am unable to discover any other difference from *altissimum*, and as it does not seem really to be a geograpical race, *altissimum* also being found in the Balkan region, it is almost going too far to give it a name as a variety. However, for greater clearness I shall call it var. *Biebersteinii* =

* So Moench, Suppl. p. 149 (1802), says of his *linearifolium*=*italicum*, L., "caule erecto simplici, spicis foliis brevioribus."

† *E. luteum*, Lap., Abr. Pyr. p. 91, is said by the author to be covered with pungent hairs, long and yellow, as well as the flowers; but there is not a word to suggest that the corollas themselves are yellow, except the erroneous reference of the name to Desfontaines, who has no *E. luteum*. Of course, his *E. flavum* was intended, which, however, is an altogether different species.

Echium asperrimum, MB. (non Lam.) Fl. Taur. Cauc. i. p. 135 (1808), where the diagnosis, quoted from the author's Tabl. Casp. (1798), runs "E. strigosum ramosum, spicis axillaribus conjugatis paniculatis." In vol. iii. p. 131 (1819), he adds "corolla constanter apud nos leucophæa, extus levitur pubescens, pilis longioribus perpaucis. Pro *E. italico* L. hoc demum habeo."

This form of *italicum* has unfortunately been confused by many French botanists * with the specifically different *E. pyrenaicum* = *E. pyramidale*,

* In judging the French specimens that I refer to one form or another of *E. italicum* to belong to the same species as those from central Italy, in spite of some discrepancy in the alleged colour of the corollas, in reducing *E. albereanum* to a mere form of *E. italicum*, and in identifying the huge *E. pyrenaicum* of Apulia with the *pyrenaicum*=*pyramidale* of the vicinity of Toulouse, I have had to rely entirely on herbarium specimens of the French plants, as it has not been possible in war-time to study them in their native haunts. It is, of course, possible that as intimate an acquaintaince with living French examples, as I have with Italian, might modify some of my opinions.

Lapeyrouse, Abr. Pyr. pp. 89–91 (1813), mentions three species of the *italicum* group for the Pyrenean region: *E. italicum*, *E. pyramidale*, and *E. luteum*. For *italicum* he quotes the old diagnosis, mentioning that the plant grows by roadsides etc., and observes "tiges droites, élancées, rameaux courts égaux," which agrees well with the Linnean *italicum*; but it is difficult to understand how he can say "fleurs distantes, secondes solitaires" of any member of this group. *Pyramidale* is spendidly described, quite in accord with Linnæus's account of *pyrenaicum*. It is "rare aux Pyrénées . . . . à foison le long des chemins près Toulouse." Its rarity in the Pyrenees may account for its misinterpretation by some authors. The diagnosis of *luteum*, being that of the totally different *flavum*, Desf., is useless, and it is only from the habitat and the observation that the species can be identified, practically with certainty, with *E. albereanum*, Naud. & Debeaux.

Bonnet, whose views have been rather uncritically adopted by Rouy in Fl. Fr. x., synonymises in Bull. Soc. Bot. Fr. xxv. p. 209 (1878), *E. luteum* as well as *E. pyramidale* with *E. pyrenaicum*, L. Mant., quoting the exsicc. Bourgeau, Fréjus, no. 285, and Billot, no. 2325. But both these are *italicum* (see my list B. nos. 4 & 5), not *pyrenaicum*. Then for *italicum* he quotes Reichb. no. 995, Jamin Pl. Alger. no. 184, and Billot 2325 bis et ter. Now Reichb. no. 995 is true *italicum*, but the other three are unquestionably *pyrenaicum*!!! (see my lists A and C). No wonder then that Bonnet's descriptions are unintelligible and contradictory.

Then Timbal-Lagrave in Soc. Agr. Pyr. Or. xxiii. p. 175 (1878), whilst insisting that *pyrenaicum* and *italicum* are different species, misinterprets both, for his *italicum* is really *pyrenaicum*, and his *pyrenaicum* or *pyramidale* is not Lapeyrouse's plant but obviously *albereanum*, a variety of true *italicum*. Thus and thus only can be explained his remark "*E. luteum* n'est qu'une forme de la même plante" (sc. *pyrenaicum*).

This inversion or transposition of the names prevails in Cosson's determinations, and was subsequently adopted (blindly) by Kerner. It frequently occurs in French exsiccata. I have examined 41 French examples of so-called *italicum* and *pyrenaicum* in herb. Mus. Paris. Of 26 labelled *italicum* only 11 belong to that species, the remaining 15 are *pyrenaicum*. But of the 15 labelled *pyrenaicum* only 8 are rightly so named, the other 7 being forms of *italicum*.

Such confusion has produced its natural result in the amalgamation of the two species by Grenier & Godron, by Coste, and even by de Coincy, whose views on European species are not so infallible as on Algerian. The amalgamation is a mere counsel of despair, due, I think, to confining attention to differences of outline and ramification, and disregarding other characters.

Lap., especially by De Candolle in Prodr. x. p. 23 *, where the two are confounded under the name of *E. pyramidatum*, so as to make that name, apparently so suitable, useless to indicate the form spoken of here, not to mention the risk of confusion between two such similar words as *pyramidatum* and *pyramidale*.

J. Bauhin's figure of *E. albo flore majus*, already referred to, seems to represent this variety, to which the specimens in my list B are referable.

The form of *italicum* called *Echium luteum* by Lapeyrouse, with an inadequate diagnosis, and rediscovered in 1874 by M. Naudin in the range of the Albères above Collioure, and by him named *E. albereanum*, requires some notice, especially as it has been regarded by Rouy as closely allied to *E. pyrenaicum*, with which it has no resemblance or relationship. It is described by Debeaux and Naudin in Soc. Agr. Pyr. Or. xxiii. p. 175 (1878), from examples cultivated by Naudin, as "dressée-hérissée, très rameuse dans sa moitié supérieure, de plus de 1 mètre de hauteur, et pluricaule dès la base . . . . les fleurs . . . . formant par leur ensemble une vaste panicule lâche, diffuse et très ramifiée." But the specimens I have seen *ex loco classico* at Sorède, collected by L. Conill, of which the individuals with a broad panicle were distributed as *italicum* var. *pyramidale* (though utterly unlike *pyramidale*, Lap.), and those with a narrow inflorescence as *italicum* var. *albereanum*, cannot be separated from *E. italicum*. Both the narrower and the broader forms are intermediate between *italicum altissimum* and var. *Biebersteinii* as far as ramification is concerned, nor can I see any other distinctive character *in sicco*. There is some conflict of evidence as to the colour of the corollas, which are stated to be bluish white or slightly pinkish by Roumeguère in Soc. Agr. Pyr. Or. xxii. p. 163 note, but yellowish white, with an occasional pinkish blush, but not pale blue, by Naudin, *l. c.*

A much more remarkable form—var. *siculum*, mihi = *E. italicum*, auctt. sic.—replaces typical *italicum* in Sicily. Where I have collected it in the stony fields of the province of Syracuse, it is a relatively low-growing but broad plant, with a forest of branches, spreading horizontally, when fully developed, in every direction ; but their arrangement is not pyramidal as in *pyrenaicum*, the lower ones not markedly exceeding the middle ones. The arrangement of the cincinni, the dull white corollas and filaments, and the size of the flowers are those of *italicum* not of *pyrenaicum*, from which it is also distinguished by the very yellow (*in sicco*) indumentum. This is extraordinarily copious ; on the stem it is long, patent and rigid, and so close as completely to conceal the surface.

Todaro's well-known exsiccata do not show the peculiar habit, as they are

* The treatment of the genus *Echium* is one of the weakest parts of the 'Prodromus.' The Borrageæ were not completed by Aug. Pyr. de Candolle before his death, nor written *de novo* by his son. It is to be remembered that neither father nor son saw the Linnean specimens or even the plants of the 'Flora Graeca.'

only scraps of plants, gathered in a very early stage, but they have the thick yellow coat of bristles. My list C contains the only herbarium specimens that I have yet met with of var. *siculum*.

I have not seen sufficient material from Asia Minor and beyond to attempt to determine or discuss the Oriental forms. Those that I have seen are referable to *italicum* sensu lato, not to *pyrenaicum*.

To conclude : *Echium italicum*, L., regarded as specifically distinct from *E. pyrenaicum* (L.), Desf., presents at least three or four marked forms in Europe :—

1. *typicum* = *E. altissimum*, Jacq. = *E. linearifolium*, Moench, Suppl. p. 149 (1802). See specimen list A.
2. var. *luteum* (Lap. pro specie) = *E. albereanum*, Deb. & Naud. See specimen lists A and B.
3. var. *Biebersteinii*, mihi = *E. asperrimum*, M.B., non Lam. = *E. pyramidatum*, DC. pro parte. See specimen list B.
4. var. *siculum*, mihi = *E. italicum*, Guss., Lojac, et auct. sic. omn. See specimen list C.

To come to *E. pyrenaicum* * ; this species first appears in Sp. Pl. ed. 1 as var. *β* of *italicum* to correspond to the *Lycopsis* of C. Bauhin. Then in ed. 2, after *Lycopsis* has again been quoted, there is added, "corollis minoribus, extus præsertim superne pilosis, et magis regularibus ab *E. italico* differre videtur, nisi hæc omnia e loco." This is no help to the identification of var. *β*, for in *pyrenaicum* the corollas have indeed more and longer hairs than in *italicum*, but they are neither smaller nor more regular. In the Appendix, p. 1678, Linnæus refers to Hudson's Fl. Angl., which had appeared in the

* I fear that it must be called *pyrenaicum*, Desf. Fl. Atl. i. p. 164 (1797–1798), as the rules will hardly allow us to say *pyrenaicum*, L. Mant. (1771), in spite of the occurrence of the name in the 'Mantissa' and the use of it as specific by Linnæus in his unpublished MS. and herbarium, and of its quotation by Willdenow, Sp. Pl. i. p. 786 (1798). These dates are correct, notwithstanding those that appear on the titlepage of Willdenow's first volume, and in some copies of the 'Flora Antlantica.' For evidence of the true date of Fl. Atl. i., see the note to *E. australe* in my paper on "Five Critical Species of *Echium*," *supra*, p. 368.

Unfortunately, a date so late as 1797–1798 admits of the doubt whether this species ought not rather to be called *E. asperrimum*, Lam. Ill. i. p. 412 (1791). I think we shall be justified in rejecting Lamarck's name as ambiguous, though its claims are arguable. Poiret, Dict. Encyc. viii. p. 668 (1808), who should have known what Lamarck meant, uses the name for the compound of *italicum* and *pyrenaicum*, quoting as synonymous *italicum*, L., *altissimum*, Jacq., and *pyrenaicum*, L. Mant. Rouy also, Fl. Fr. x. p. 304, seems to consider it ambiguous, for he does not adopt it, but quotes it pro parte for both *italicum* and *pyrenaicum*. In Lam. Fl. Fr. ii. p. 451 (1778), we find *italicum* and *pyrenaicum* both under *E. italicum* ; the former as *italicum*, L. = *E. majus et asperius fl. albo*, Tourn., and the latter as var. *β* = *E. majus et asperius fl. dilute purpureo*, Tourn. But in Ill. *l. c.* Lamarck only says of *asperrimum* "E. caule ramoso, pilosissimo ; corollis calyce longioribus ; staminibus exsertis. Ex Europa australi. *E. italicum*, L. ?" The synonym *italicum* is queried, and there is no allusion to his own previous use of that name. The diagnosis would cover various other species besides *italicum* and *pyrenaicum*. So far, therefore, *asperrimum* seems

same year (1762), but the reference throws no light on either *italicum* or *pyrenaicum*, for Hudson had altogether misinterpreted *italicum* and its var. β *, neither of which grow in England or Jersey. But in Linnæus's own interleaved copy of the 2nd ed. of Sp. Pl., now in the possession of the Linnean Society, he has written opposite *E. italicum* the following note : "*pyrenaicum Ech. majus et asperius flore dilute purpureo* T. 135. Totum valde hispidum ut fere urens; corolla calyce latior (*sic* ; obviously a slip of the pen), subincarnata. Filamenta corolla longiora saturate rubra. Anth. cæruleæ. Sna. lævia, apice subtrigona, quasi dente intermedio s. interiore productiori. Lycopsis monspeliaca flore dilute purpureo Moris. blæs. Magn. monsp." This is obviously a description from life of the plant grown in Hort. Ups., of which a specimen labelled "*pyrenaicum*" is in the herbarium. The underlining of the Bauh. Pin. 255 in this copy indicates that at the time he had a specimen in the herbarium. There cannot be a shadow of doubt that the description refers precisely to the plant called *pyrenaicum* by Desfontaines also and *pyramidale* by Lapeyrouse, Abr. Pyr. p. 90 (1813). I have examined Tournefort's own specimen of *E. majus et asperius fl. dilute purpureo* (no. 586 in his herb.) and found it identical with that of Linnæus's *pyrenaicum* and with authentic Lapeyrouse specimens of *pyramidale* at Kew and Mus. Brit.

It is to be noted that in this MS. entry, Linnæus uses the name *pyrenaicum* as that of a species, and not as var. β of *italicum*. He does the same on the sheet in the herbarium. It is impossible to guess why in the published description in the 'Mantissa' of 1771, p. 334, he should have headed it β and not with the name *pyrenaicum*, though the language there used seems to indicate that he still regarded it as specifically different from *italicum*.

The 'Mantissa' varies very slightly from that MS. entry. After quoting as synonyms for var. β those of Tournefort and Morison there follow the words "*Echium pyrenaicum vulgo*," and then "Simillimum *E. italico*, hispidum et fere urens, stimulis albis. Cor. calyce non latior, subincarnata (nec alba), infundibuliformis, fere regularis, calyce duplo longior, extus pubescens pallidiorque. Filam. duplo longiora, saturate rubra. Anth. cæruleæ. Sem. lævia, apice trigona, quasi denticulo intermedio s. interiore productiore."

A most admirable description, agreeing perfectly with that given by

to be a *nomen dubium* to be rejected. On the other hand, Lamarck's immediately following species, *E. elongatum* (which puzzled Poiret), is defined "E. caule erecto piloso, longissime spicato; corollis vix calycem superantibus, staminibus exsertis. Fl. albi, parvi, sessiles." If this diagnosis be compared with that of *asperrimum* it will be noticed that it contains three characters by which *italicum* (*altissimum*) differs from *pyrenaicum*, viz.: the erect stem and very long spike, the smaller corollas, and their white colour. Now Lamarck's herbarium contains two specimens bearing on the question. One, labelled "*E. elongatum*, Lam., an *E. majus asperius fl. albo*?" is *E. italicum*. The other, labelled "*E. italicum. E. asperrimum*, Lam. Ill.," is *pyrenaicum*. Considering the way in which Poiret and Rouy have treated *asperrimum*, I hardly think these labels are cogent enough to force us to abandon the appropriate, admirably described, old name of *E. pyrenaicum*.

* See my *Echia* of Miller's 'Gardener's Dictionary,' *infrà*, p. 433.

Lapeyrouse of his *pyramidale*. The herbarium specimen, taken from a plant grown in Hort. Ups., consists of one leaf only and two flowering branches without the main stem, but is quite unmistakable. A list D of characteristic specimens of *E. pyrenaicum* will be found below. The following description is founded on French exsiccata from Toulouse, but the Apulian plant seems to be larger, with more stiffly horizontal branches; this, however, may be due to the impossibility of exhibiting full-sized French plants in herbarium sheets. What I must emphasise is that in Italy *pyrenaicum* and *italicum* are totally different, and inhabit separate areas, as was long ago pointed out by Tenore and Gussone (*cf.* Ten. Fl. Nap. v. p. 330, and Guss. et Ten. in Att. Ac. Nap. v. p. 431, 1843).

It is notorious that *pyrenaicum* alone is found in Algeria ; it predominates in Spain, where *italicum* apparently only just crosses the border into Catalonia. In fact, it is in southern France alone that the two species are often found in proximity, and it is precisely there that puzzling forms occasionally occur—whether as hybrids I cannot say.

The Balearic Islands furnish a form with extra hard bristles, but not otherwise distinguishable. This is *E. italicum*, var. *balearicum*, Porta & Rigo in N. Giorn. Bot. It. xix. p. 318 (1887), but it must be referred as a variety to *pyrenaicum* and not to *italicum*.

ECHIUM PYRENIACUM ; (planta Tolosana) semper unicaule, caulibus secundariis nullis, aut rarissime præsentibus.

Caules c. 50–60 cm. alti., ramosi, ramis inferioribus patentibus, (*a*) in planta luxuriante usque ad 45 cm. longis, ramulos floriferos 15–20 gerentibus; ipsis ramulis aut simplicibus fere a basi floriferis, aut apice in cincinnos geminos fissis ; (*b*) in planta debiliore non ultra 30 cm. longis, basi usque ad 10 cm. foliiferis non floriferis, superne cincinnos abbreviatos simplices, raro geminos, gerentibus ; ramis vero superioribus, simplicibus, ad cincinnum unicum elongatum reductis.

Cincinni virginei parum scorpioidei (multo minus quam in *E. italico*), in ramis inferioribus laterales pauciflori, quasi ad florum glomerulos post anthesin parum elongatos reducti ; in ramis vero superioribus simplicibus 10–20-flori, ideoque post anthesin usque ad 10–15 cm. elongati, suberecti.

Inflorescentia pyramidalis, latitudine in plantis evolutis altitudinem æquante vel etiam superante ; ramis aut horizontalibus, aut (quia inter plantas circumstantes constrictis ?) adscendentibus, ita ut plures altitudinem axis centralis attingant *.

* I suppose this is the character meant by the phrase "rameaux atteignant presque tous la même hauteur, ce qui donne à la plante l'aspecte conique," which Bonnet uses of his *italicum*, by which, as explained in a previous note, he intends *pyrenaicum*. But the same words are used by Rouy, who does not seem to have noticed that Bonnet transposes the two names, of his own *italicum* which is not *pyrenaicum*. I am afraid this takes away nearly all the value of Rouy's account of these species. And, indeed, the phrase indicates an arrangement of branches which would not produce a cone, but an inverted cone.

Flores in cincinnis sicut in congeneribus dispositi, in ramis inferioribus magis, in superioribus minus conferti ; bracteis lanceolatis, basi latioribus quam in *E. italico*, calycem (laciniis inclusis) usque ad 10 mm. longum parum superantibus.

Corollæ parvæ, tubo leviter geniculato ("tube coudé," Lap.), minus quam in *E. italico* regulares, et paululum quam in eo longiores (15–18 mm.) extus pilosissimæ, pilis albis strigosis longioribus quam in *E. italico*, carneæ *, filamentis pulcherrime rubris (etiam in sicco fusco-rubris), antheris cæruleis. Stamina exserta, sed multo minus quam in *E. italico*.

Folia radicalia angustissime elliptica potius quam lanceolata (20 × 4 cm., 15 × 3·5 cm., 10 × 2 cm.), ideoque forma ab illis *E. italici* nonnihil diversa.

Indumentum asperrimum, tactu urens, minus quam in *E. italico* confertum, e pilis albis non lutescentibus (ideoque tota herba etiam in sicco grisea), valde inæqualibus, nonnullis apice stellatis.

As exsiccata only consisting of branches torn off, or, if entire, of exceptionally small inviduals, do not give an adequate idea of the normal habit of this very large species, I add a note made on the spot from four Apulian specimens gathered in late autumn, in seed, by the roadside near Taranto, where the species is very abundant. The two larger are one metre high and 70 cm. broad ; the two smaller measure 65 by 55 cm. The larger plants have from 20 to 30 branches, spreading in every direction, erecto-patent in the larger, horizontal in the smaller specimens, the lowest branches being as much as 50 cm. long. Each of the longer branches bears 10 to 20 scattered branchlets, pointing in every direction. Of these branchlets the lower are again branched into 5 to 10 subunilateral cincinni, with their distichous flowers on the upper surface, but the upper branchlets consist of single cincinni. These cincinni are nearly all simple, only occasionally bifid. Even the most developed only bear about 10 flowers, forming at first tight glomerules, but lengthening later to about 10 cm. The fruiting calyces overlap each other, each covering about half the calyx next above. Bracts and calyx-segments are lanceolate and very hispid. The fruiting calyx is not enlarged nor concrete at the base. The plant is everywhere hispid with white, spreading, stinging setæ that give the whole a pale grey appearance in autumn.

The root-leaves of the young plants first appear in November. Their surface is dark green and almost hairless in the intervals between the incipient tubercles, which show as lighter green pustules bearing hardly any hairs. When radical leaves are present in herbarium specimens they are obviously broader and shorter than in *italicum*, more tuberculate and less

* I am not sure that albinos of *pyrenaicum* may not occur occasionally, just as they do in *E. vulgare* and *E. plantagineum*. This, or hybridity, may account for the very few examples I have seen—all from France, where both species are found—that are not at a glance referable to *italicum* or to *pyrenaicum*.

hairy. But the characters, by which incomplete specimens are most easily recognised in herbaria, are the grey not yellow indumentum, the shorter hairier corollas with less remarkably protuding stamens, and the dark filaments. The difference in shape of the corolla-tube is not easy to see *in sicco*.

List A.

Echium italicum, L. = *E. altissimum*, Jacq.

1. ex Herb. Jacq. in Mus. Brit. probably cult. (as *altissimum*).
2. Fl. Austr. Hung., no. 3714, Promontor, Hungary (as *altissimum*, but identical with no. 12 below).
3. Richter, Fl. Hung., Ofen ; also in Baenitz as from Buda-Pest (as *italicum*).
4. Schultz, Herb. Norm. 2868, Wolfsthal prope Budam (as *altissimum*).
5. Heuffel in Herb. Gay, from the Banat (as *italicum*).
6. Wierzbicki, from Oravicza in the Banat (as *italicum*).
7. Sagorski, Fl. Herceg., form Mostar (as *altissimum*).
8. Sintenis, 1873, no. 302, Babadagh in the Dobrudja (as *italicum*).
9. Pichler, 6, vi. 1885, from Spalato (as *italicum*).
10. Huter, 24, v. 1867, from Ragusa (as *italicum*).

10 *bis*. Reichenbach, Fl. Germ. exsicc. no. 995, from Fiume (as *italicum*).

11. J. S. Mill, Rimini on the road to Ravenna (as *altissimum* = *italicum* Lehm., non Linn.).
12. Fl. Austr. Hung. no. 3715, from Verona (as *italicum*, but identical with no. 2 above).
13. Fl. Ital. Exs. no. 940, from Florence (as *italicum*).
14. Webb in hb. Rouy, Roma extra portam Salaram (as *italicum*).
15. Arcangeli in hb. Florent., from Stilo in Calabria (as *italicum*).
16. Reverchon, Pl. Sard. 1882, no. 245, from Tempio in Sardinia (as *italicum*).
17. —— Pl. Cors. 1878, no. 49, from Bastelica in Corsica (as *italicum*).
18. Kralik, Pl. Cors. no. 699, from Zicavo in Corsica (as *italicum* ; this no. is quoted in Rouy, Fl. Fr.).
19. ex hb. Grenier in Mus. Paris, from Hyères (as *italicum*).
20. Thuret, 1868, no. 61, from Antibes (as *italicum*).
21. Loret, 1, vi. 1851, from Le Luc (Var) (as *italicum*).
22. Naudin in Mus. Par., from Collioure with the obs. " fleurs très petites blanc-bleuâtres, très différent de l'*E. italicum* qui abonde à Collioure," is typical *italicum* showing that his conception of *italicum* was not that of Linnæus. This plant became var. *albereanum*, Naud.

23. Herb. Conill. in hb. Bailey, from Sorède in Pyr. Or. (as *italicum* var. *albereanum*).
24. Sennen, Pl. Esp. no. 572, from Cabanas, in Catalonia (as *E. pomponium*, var. *Paui*, Sen. ; it is not a form of *pomponium*).

List B.

Echium italicum, L., var. Biebersteinii, mihi.

1. Unio itin., in fossis c. urbem Perpignan (as *luteum*, Lap.).
2. ex hb. Conill in hb. Bailey, Sorède Pyr. Or. (as *italicum* var. *pyramidale*).
3. Soc. Cénomane, 1901, no. 554, from Sorède, identical with no. 2 (as *italicum* var. *pyramidale*, corrected by Sudre in his herb. to *luteum*).
4. Bourgeau, Env. de Fréjus, no. 285, from the Esterel (as *pyrenaicum*, det. Coss. This is quoted for *pyrenaicum* by Rouy in Fl. Fr. x. p. 305, but is not that species).
5. Billot, no. 2325, from the Monte Pisano in Tuscany (as *italicum*, but quoted by Rouy for *pyrenaicum*, perhaps from a confusion with Billot, 2325 *bis* and *ter*).
6. Frivaldsky in hb. Hooker, from Rumelia (as *asperrimum*, M. Bieb.).
7. —— in Mus. Brit., from Carlova (as *asperrimum*, M. Bieb.).
8. Stribrny, vi. 1894, from Sadovo in Bulgaria (as *italicum*).
9. Adamovic, Pl. Balcan. vi. no. 190, from Voden in Macedonia (as *italicum*).
10. Tardent in hb. Gay, from Bessarabia (as *asperrimum*, M. Bieb.).
11. Richter in hb. Kew, from Odessa (as *asperrimum*, M. Bieb.).
12. Count Puschkin, 1783–1803 in hb. Kew, from Caucasia (as *asperrimum*, MB.).
13. Aucher Eloy, hb. d'Orient no. 2397, from Greece (as *pyrenaicum*).
14. Zuccarini in hb. Kew, from Nauplia in Greece (as *E. pyrenaicum*, L. = *E. asperrimum*, M. Bieb.).
15. Sieber in hb. Kew, from Canea in Crete (as *italicum*).
16. Reverchon, 1886, sine numero, from Canea (as *italicum*).

List C.

Echium italicum, L., var. siculum, mihi.

1. Todaro, Fl. Sic. no. 1227, from Sclafani (as *italicum*).
2. hb. Lacaita, from Ragusa prov. Siracusa (as *italicum* var. *siculum*).
3. hb. Florent. contains similar Sicilian specimens from Palermo, Castelbuono and Girgenti, but I have not examined them carefully.

List D.

Echium pyrenaicum, L.

1. ex hb. Vaillant in Mus. Paris (as *E. majus et asperius fl. dilute purpureo*).
2. ex hb. Pourret in Mus. Paris from Narbonne (as *italicum*).
3. Lapeyrouse in hb. Gay, sine loco (as *pyramidale*). Other authentic specimens from Lapeyrouse are at Mus. Brit. and in hb. Smith.
4. Bentham in hb. Kew, from Villefrance près Toulouse (as *pyramidale*).
5. —— from Restinclières (as *pyrenaicum*).
6. hb. Loret in Mus. Par., from Toulouse (as *pyrenaicum*).
7. —— from Viviers (as *italicum*).
8. Billot, no. 2325 *bis*, from Carcassonne (as *italicum*, L., non Lehm.).
9. —— *ter*, from Fouras in Charente Inférieure (as the last).
10. Magnier, Fl. Select. 1250 *bis*, falaises de Bidart, Basses Pyr. (as *italicum*).
11. Reverchon & Derbez, Pl. Fr. no. 249, from Bollène (as *pyrenaicum*).
12. J. S. Mill in hb. Kew, from La Dochelle (as *pyramidatum*).
13. Bourgeau, Pl. Hisp. 1852, sine numero, from Fuente de la Higuera, Spain (as *italicum* det. Cosson).
14. Gandoger, Fl. Hisp. Exs. no. 258, Renteria in Guipuzcoa (as *pyrenaicum*).
15. ex hb. Fernandez in hb. Rouy, Guadalajara, Spain.
16. hb. Rouy, from Sierra de Maimon above Velez Rubio (as *italicum* altered to *pyramidale*).
17. Bourgeau, Esp. 1850, from Fuensanta by Murcia (as *italicum*).
18. Fl. Ital. Exs. no. 2129, from Spinazzola, Prov. Bari (as *italicum* var. *pyramidatum*).
19. Martelli in hb. Florent., from Manfredonia.
20. Groves in hb. Florent., from Otranto.
21. —— from Gallipoli.
22. Rabenhorst in hb. Kew, from Gargano (as *E. gaditanum*, Boiss., which is ridiculous).
23. Reverchon, Pl. Alger. 1897, no. 243, from M. Babors (as *italicum* var. *pyramidale*).

All Algerian specimens called *italicum* are *pyrenaicum*.

E. pyrenaicum var. balearicum, mihi.

24. Porta & Rigo, 21. viii. 1885, from Majorca (as *italicum β balearicum*).

(III.) **ECHIUM LUSITANICUM**, Sp. Pl. p. 140 (1753). Of this species Linnæus says little and adds no more in his later works. It is defined *corollis stamine longioribus*, and two synonyms are quoted, one from Royen, the other from Tournefort, but the latter with a note of interrogation. The habitat "*in Europa australi*" is too indefinite to give any clue; the definition

is not really applicable to any European species except *E. parviflorum*, Moench, *E. arenarium*, Guss., and the small-flowered form of *E. vulgare* known as *E. Wierzbickii*. These are all out of the question and have never been suggested as the species intended by Linnæus; we are therefore dependent on the synonyms, and on the specimen that exists in the herbarium, to ascertain what Linnæus meant.

Both synonyms and specimen belong to the very remarkable perennial *Echium* from Portugal and north-western Spain that has been named by Sampaio * *E. Broteri*, because it is the *Echium italicum* of Brotero, non Linn., = *E. italicum* var. *lusitanicum*, Hoffmg. et Link. I have flowered at Selham in Sussex in 1918 several plants of this *Echium* from seed sent by Prof. Coutinho of Lisbon. In good soil from ten to twenty ascending flowering stems issue from beneath the great central rosette of leaves, which remains flat on the ground. The inflorescence of each of these lateral stems, when normally developed is not unlike that of *E. vulgare*, but if the growth of their axis has been checked from any cause the upper cincinni when fully unfurled in fruit appear almost corymbose, as is the case in the Linnean specimen.

Brotero's description of his *E. italicum* in Fl. Lus. i. p. 290 (1804), is very full. Link in Hoffmg. & Link, Fl. Port. i. p. 185 (1809), calls it "accurata." Other characterisations may be read in Coutinho, as Boraginaceas de Portugal in Bol. Soc Broter. xxi. p. 113 (1905), in the same author's Fl. Port. p. 499 (1913), and in Merino, Fl. de Galicia, ii. p. 155 (1906). Coutinho gives characters to distinguish the species from the nearly allied *E. salmanticum*, Lag. = *E. polycaulon*, Boiss. Brotero says: "Caules quinque ad duodecim ex eadem radice, sub rosula foliorum radicalim, primum obliqui, dein incurvati, erectiusculi, bipedales et ultra . . . . folia radicalia in orbem prostrata, pedalia et longiora, ad medium biuncialia aut latiora, lanceolata . . . . spicæ ad quinquaginta et ultra, spiraliter recurvæ, fere ex imo caule usque ad ejus apicem." The habit of *E. salmanticum* is thus described by J. Gay in a MS. note on plants grown in the Jardin des Plantes: "caulibus ex una radice pluribus, rosulæ centrali subjectis . . . . Il forme une énorme touffe de 2–3 pieds haut." This character in *E. salmanticum* led Gay to suppose that it was the plant intended by Brotero, and in his MS. notes he proposed the name *E. Broterianum* for it, a misnomer fortunately not published. Gay also knew the true *E. Broteri*, which he regarded as *E. lusitanicum*, and indicated the distinctions. The corollæ are quite different in the two species.

The habitat known to Brotero was "in sabulosis ad Villa Franca, ad Mundam prope Conimbricam (Coimbra) et alibi in Beira." Hoffmg. & Link say "contrées élevées du Portugal, entre Caldas de Gerez et Portela do Homem en abondance. De même dans la Serra d'Estrella, d'où la rivière du Mondego la transporte dans les sites inférieurs près de Coimbra, etc." It was collected

* In herb. Acad. Polyt. Brot. et in Lusitano, 12 Jan. 1900, ex Coutinho in Bol. Soc. Brot. xxi. p. 113 (1904).

in Galicia by Pourret in 1802 and has since been found there by Merino in three places in the frontier province of Orense.

The five modern specimens from Portugal I have been able to inspect are:—

1. Herb. Hort. Bot. Conimbr. (in Herb. Kew), no. 470. Coimbra, 1878. A very imperfect example.
2. Herb. Murray (in Mus. Brit.), Caldas de Gerez, leg. R. P. Murray, 16. vi. 1887.
3. Herb. Murray (in Mus. Brit.), Gerez, leg. R. P. Murray, vi. 1888.
4. A specimen kindly sent me by Prof. Coutinho, labelled: "*Echium Broteri*, Samp. In Transtagana montana, circa Marvao prope Beiram Majo, 1913." This is accompanied by some separate fruiting spikes.
5. A fruiting specimen given me by Prof. Henriquez of Coimbra.

All the examples in flower have remarkably protruding stamens. It must therefore be admitted at once that the character "*corollis stamine longioribus*" is a grave difficulty, and it will be returned to below.

To come to the synonyms:—

A. What is *E. amplissimo folio Lusitanicum*, Tourn.? There is no specimen so labelled in Tournefort's herbarium, but no. 587 without any original label is undoubtedly the plant to which he gave that name, and was ticketed by J. Gay in 1834 "Verosimiliter *E. ampliss. folio lusit.*; *specimen minus evolutum*=*Ech. lusitanicum* Linn. Poir. etc." I have examined this specimen; it is precisely *E. Broteri*. Then in Herb. Mus. Paris there is a cover containing two pieces, one in flower, the other in fruit, ex herb. Vaillant, labelled by him "*E. ampliss. fol. lusit.*" and subsequently by Desfontaines "*Ech. lusitanicum* Linn. ex synon." Both pieces are *E. Broteri*. Herb. Jussieu contains three specimens that are *E. Broteri*; two of them under no. 6605, of which one from herb. Isnard is labelled "*E. ampliss. folio lusit.*; *E. lusitanicum folio cubitali* T.; the other from herb. Charles "*E. ampliss. folio lusit.*"; the third under no. 6606 is labelled "no. 48 *Ech. undulatum* Pourr. Gallice" (*sc.* Galicia) "envoyé par M. Pourret 1802."

Herb. Gay at Kew contains a similar specimen given him by A. de Jussieu. As Gay's note confirms the above determinations of the specimens at Paris it is here transcribed:—

"*Echium lusitanicum* L. (ex. herb. Juss.)=*E. amplissimo folio Lusitanicum* Tourn. Inst. Herb. Isn.! Specimen falso nomine inscriptum in herb. Juss. verisimiliter cultum. Adr. de Juss. dedit Xbr. 1834. *E. amplissimo folio Lusitanicum* Tourn. etiam in herb. Vaill. . . . *E. undulatum* Pourr. in herb. Juss. (anno 1802 e Gallecia hispanica a Pourretio missum) huc spectare videtur, specimen vero valde imperfectum non nisi inferiorem caulis partem sistit. Deest in herb. Linn. [quoting

Lehmann]. Exstat in herb. Tournef. sine nomine et loco. Racemi in specimine Tournefort minus quam in meo evoluti, dimidio breviores." Then on another slip "Xbre. 1834. Fragment d'un échantillon conservé dans l'herbier de Tournefort* sans nom et sans localité, que je suppose appartenir à l'*E. lusitanicum* de Linné. Cette même plante se trouve dans l'herb. de Vaillant! sous le nom de *Ech. amplissimo folio Lusit.* Tourn. Inst. = *E. tingitanum altissim. flore variegato* H. Ox. 3. 440, no. 5. La plante de ces deux herbiers a les épis de moitié plus courts qu'il ne sont dans l'herbier de M. de Jussieu, mais cela tient probablement à l'âge des échantillons, moins avancés, moins développés dans l'herbier de Tournefort et de Vaillant."

It is thus quite certain that Tournefort's synonym refers to *E. Broteri*, Samp. There are several old specimens agreeing with *E. Broteri* at the British Museum, which bear out this conclusion and moreover indicate that the plant was in cultivation in the 18th century. I will quote :—

(1) Herb. Sloane, vol. 166, p. 109, among Petiver's Hort. Sicc. Hispaniæ etc., comm. Salvador and labelled "*E. amplissimo folio Lusitanicum* Tourn." Though Salvador lived at Barcelona, it is clear from other Portuguese species sent by him to Petiver that he collected in Portugal.

(2) Herb. Sloane, vol. 198, p. 48, among Petiver's Pl. Rayanæ, also labelled *E. amplissimo*, etc.

(3) Hort. Cliff. labelled by the first hand *Echium sylvestre hirsutum maculatum*, C. B. P., which words have been cancelled (by the same hand?) and replaced by *creticum angustifolium rubrum.* The unknown second hand added *creticum.*

This specimen is an instance of the utter untrustworthiness of the names written in Herb. Hort. Cliff.

(4) Herb. Gronovii, labelled *E. folio amplissimo* etc., Tourn., then *E. corollis stamine longioribus*, but the last phrase has been cancelled and replaced by *E. caule erecto piloso* etc., the Linnean diagnosis of *E. italicum.* This alteration points to an observer who had noticed the agreement of the specimen with *E. italicum*, Brot., but overlooked the fact that Brotero's is not Linnæus's *italicum.*

(5) Hort. Chelsea. A fine specimen labelled by Solander first ? *italicum* and then *Echium lusitanicum*, L. M.

B. Royen's synonym, "*E. caule simplici, foliis caulinis lanceolatis sericeis, floribus spicatis lateralibus*, Lugdb. p. 407," is uselessly indefinite in itself, but Lehmann, Asperif. p. 452, under *E. lusitanicum* (which to him meant *E. Broteri*) observes, "asservantur in herbario Vahliano exemplaria ab ipso Royeni Museo a Brugmanno data." It is therefore clear that this synonym also refers to *E. Broteri.*

The Linnean specimen bears no writing in the hand of Linnæus himself, but an old label in that of Jan Burman saying "*Echium lusitanicum folio amplissimo* Tourn." Now Burman's entire herbarium was brought by his

* Unfortunately this fragment is missing at Kew, perhaps lost when the plants were mounted.

son to Linnæus in 1760. Therefore Linnæus cannot have seen this specimen when he wrote the diagnosis of *lusitanicum* for the Sp. Pl. of 1753, but that he saw it afterwards is proved by the name *lusitanicum* being underscored in his copy of the twelfth edition of the 'Systema Naturæ' of 1767 *. The name *lusitanicum* now on the sheet was written by Linn. fil., who ought to have known what his father meant, notwithstanding that Sir J. E. Smith has pencilled a note of interrogation after the name. The specimen is unmistakably *E. Broteri*. It consists of two leaves measuring respectively 45 × 8 and 30 × 14 cm., covered with rather sparse soft hairs, which on the upper surface only are tubercle-borne. There are no stem-leaves. There is also the upper part of a fruiting stem, forming a panicle 15 × 14 cm., composed of six cincinni, erecto-patent and very much elongated in the fruiting stage, the uppermost springing close together so as to give to the whole a false appearance of being corymbose. Each cincinnus is 10–15 cm. long, with 30–40 or more small, almost sessile flowers. The bracts are lanceolate, equal to or shorter than the calyces, of which the teeth are lanceolate, acute, 5–7 mm. long. The whole inflorescence is rough with white setaceous hairs on white tubercles. Very few corollas remain, but they have evidently been small, subregular, and only slightly dilated at the throat. They are too much withered for the character and length of the stamens to be defined. Owing to the advanced stage in which it has been gathered the elongated, erecto-patent cincinni look very unlike those of examples in an early flowering stage. But this change of superficial appearance occurs in most species.

Are we then to decide that *E. Broteri* is the species indicated by Linnæus under the name *lusitanicum*, which therefore must be used for it? Surely we must, seeing that this is the plant referred to in the two synonyms and represented by the fine specimen in the herbarium, notwithstanding :—

(*a*) the name on the specimen not being in Linnæus's own hand,
(*b*) the phrase "*corollis stamine longioribus*,"
(*c*) the baseless opinion of Brotero that by *lusitanicum* Linnæus meant a form of *vulgare*,
(*d*) the opinion of Link, based on a mistake, that the *lusitanicum* of Linnæus was *E. plantagineum*,
(*e*) the erroneous statement of Link and Lehmann, uncritically accepted by later authors, that Linnæus's herbarium contains no specimen of *E. lusitanicum*.

The objections shall be taken in order :—

(*a*) That Linnæus did not himself write the name *lusitanicum* on the sheet with the specimen may have been due to his old doubt as to the identity of Royen's and Tournefort's synonyms, indicated by the query appended to the

* See Dr. Daydon Jackson's 'Index to the Linnean Herbarium,' p. 8, as to Linnæus's use of underscoring.

latter in the 'Species Plantarum.' I think we may be fairly sure that when he wrote that work he had not seen any specimens that he knew to be Tournefort's *Echium amplissimo folio lusitanicum*, for the example in Hort. Cliff. was unrecognised by him. Why he did not further deal with the species after he had Burman's specimen it is useless to speculate. But in all the circumstances we certainly cannot take the absence of his autograph as any indication that he thought the specimen was not his *lusitanicum*.

(*b*) This phrase is the only serious objection to the identification of *E. lusitanicum* with *E. Broteri*, the stamens of the latter being exserted, especially the two lowest, as noticed by Brotero. But in the specimen the very few remaining corollas are in such a state that the incompatibility of the phrase with the plant might be overlooked. Yet we cannot rely on such an explanation, which would throw no light on the reason for the original use of the phrase in Sp. Pl. We shall, I think, be justified in assuming either that *longioribus* was a slip of the pen or of an amanuensis for *brevioribus*, or that it was a mistake due to some misunderstanding that cannot now be traced. "Quandoque bonus dormitat Homerus."

(*c*) Brotero says under *E. vulgare*, "*Echium lusitanicum* L. quod passim occurrit, est varietas staminibus corolla vix brevioribus." How could Brotero know this with nothing but Linnæus's brief phrase to go upon? He could not be referring to the *Wierzbickii* form of *vulgare, quia passim non occurrit*, least of all in Portugal. Indeed, the *vulgare* of Brotero is supposed by all later authors to be *tuberculatum*, Hoffmg. et Link.

(*d*) and (*e*) Almost simultaneously Link took the *lusitanicum* of Linnæus to mean *E. plantagineum*. His suggestion and that of Brotero are equally untenable and mutually destructive. In 1804, the very year of publication of the Fl. Lus., Link sent to Smith two little flowering scraps, each about 2½ inches long, of *E. plantagineum* with this ticket :—

2. *Echium lusitanicum*? Ad *plantagineum* quoque bene convenit. F. . .* in Lusit.

These scraps may be seen on the sheet of *E. plantagineum* in Herb. Smith, who has only written against them "Portugal, Prof. Link 1804."

No doubt these fragments are what induced Smith to insert a query after Linn. fil.'s determination of specimen M as *E. lusitanicum*. We can only guess that some letter of his acknowledging them must have been misunderstood as meaning that in Herb. Linn. there is no specimen of *E. lusitanicum*. Indeed, Link, in Fl. Port. ii. p. 186, went so far as to identify not only *E. lusitanicum*, Mill. (which is identical with the Linnean *lusitanicum*), but even Tournefort's *E. amplissimo folio Lusitanicum* with *E. plantagineum*, which is manifestly absurd. He then goes on "*E. lusitanicum* in herbario

* I cannot read the two letters after F.; possibly meaning "Frequens."

Linneano non exstat. *Echium lusitanicum* Milleri et synonymon Tournefortii hujus loci sunt fide herbariorum." (Exactly contrary to the fact.) "Expurgatur itaque *E. lusitanicum* ex Systemate. Nostram plantam esse *E. plantagineum* Linn. litteris confermavit cl. Smith." Yes; Smith's letter may indeed have confirmed that Link's specimen was *E. plantagineum*, but that has no bearing on the identity of *E. lusitanicum*, L.!! It is also possible that some specimen of Boerhaave's may have led Link or Smith to fancy that *E. lusitanicum* was identical with *plantagineum*. Among Boerhaave's plants in Herb. Sloane, vol. 321, p. 63, there is a piece of *plantagineum* labelled "*Anchusa lusitanica non descripta*." Link's erroneous statement "*E. lusitanicum* in herbario Linneano non exstat" has been handed down to later authors and never corrected until now. Even Lehmann says "*E. lusitanicum* deest in herbario Linneano, quod Smith in litteris," and the error has been accepted by de Coincy in a MS. note to the specimen of *E. polycaulon* in his herbarium, and by Coutinho in Borag. Port. *l. c.* (*suprà*, p. 415).

If the arguments I have adduced are not considered sufficiently convincing to justify the use of the name *lusitanicum*, L., in the sense of *E. Broteri*, Samp., the only alternative will be to make use of Sampaio's appellation and to reject altogether the Linnean name as a *nomen confusum*, for there is no other meaning that can be assigned to it.

(IV.) **ECHIUM PLANTAGINEUM** is well represented by specimens C, D, E, which are quite typical. The mark "*A 39*" on specimen D indicates that it came from one of Linnæus's correspondents whose name began with A, perhaps Alströmer, who collected in lands where *E. plantagineum* is plentiful. Smith's query is accounted for by a specimen from Hort. Paris in Herb. Banks, now at Mus. Brit., which though certainly *plantagineum* was wrongly labelled *orientale* by Solander. Moris, who inspected the Linnean herbarium, says of this specimen in Fl. Sard. iii. p. 128 "*E. orientale* H. B. sic in Linn.! herbario, non a Linnæo, aliena manu inscriptum, pertinet ad *E. plantagineum*." Specimen E was collected by Löfling, as indicated by the mark "*L. 152*," and therefore came from Spain or Portugal.

This is the only Linnean species besides *E. vulgare* that cannot give rise to any doubts. The description of the bracts and of the radical leaves and the reference to Barrelier, ic. 1026, are sufficient to establish its identity. Among other distinctive characters it possesses two that are particularly useful, because easily verified in incomplete herbarium specimens and not found combined in any other species. (1) The indumentum of the leaves is not dimorphous or composed, as in most kinds, of a carpet of short softish hairs above which longer scattered bristles project, but of bristly hairs alone, more or less tuberculate at the base according to the age and habitat of the plant. (2) The corolla is of a peculiar thin texture, not externally pubescent or velvety all over, but glabrous, with hairs on the nerves only and more or

less ciliate on the margin. The colour in life is a varying compound of blue and light purple, which generally dries blue but sometimes shows the purple tint. The corollas of *E. maritimum*, Willd. = *E. confusum*, Coincy, which by some authors has been carelessly thought to be a variety of *plantagineum*, are smaller, pubescent all over externally, and Prussian or indigo blue in dried specimens *.

The failure of pre-Linnean botanists to recognise *E. plantagineum* and its subsequent confusion with *E. violaceum* have caused much trouble. The rather wide intervals between the fruiting calyces have encouraged confusion with *E. creticum*, and the purplish corollas have led to the misappropriation of the name *violaceum* to large flowered forms of *plantagineum*. Examples from the Atlantic islands often have exceptionally large flowers—*e. g.*, Bourgeau, Pl. Canarienses anno 1845 no. 235, from Teneriffe, with corollas fully 3 cm. long and very wide-throated. Similar plants in Herb. Kew are all labelled *violaceum* by C. B. Clarke; these should perhaps be recognised as a variety, but not under that name.

E. grandiflorum, Desf., is very distinct in respect of every organ. Its reduction to a variety of *plantagineum*, accepted even by so good a judge as Ball (Journ. Linn. Soc. xvi. p. 575), is a *reductio ad absurdum*. A beautiful species from Palestine, *E. judæum* mihi, closely allied to *grandiflorum*, is wrongly determined as *plantagineum* (or *violaceum* in the same sense) in all the exsiccata I have seen: for instance, from the Haram Court at Jerusalem. leg. M. J. Fox, Feb. 1867; from Jericho in Bornmüller's It. Syr. 1897, no. 1136, and from the same place in Meyers and Dinsmore, Pl. Palæst. Maris Mortui. True *plantagineum* is also found in Palestine: e. g. Pl. Jordanicæ ex Herb. Postian. no. 526 from Sarada and no. 527 from Wady el Kefar; also from Antioch, leg. Loftus no. 71.

E. plantagineum is the species which has spread most widely in regions remote from its natural home. It is represented from the Cape of Good Hope, from Australia, where it is plentiful in grass lands round Adelaide, from the Eastern U.S.A., from Southern Brazil (leg. Chamisso), from Montevideo, and from Buenos Aires. Poiret gave the name of *E. bonariense* to the Buenos Aires plant, though it is just typical *plantagineum*.

But *E. plantagineum* is by no means uniform. Its complete specific isolation should encourage a study of its forms. The radical leaves do not always resemble those of *Plantago major*. Jacquin, Hort. Vind. t. 45 (1770), figures a narrow-leaved form as " *E. plantaginei* Linn. an varietas ? " which is quoted by Murray in Syst. Veg. ed. xiv. p. 189 as "varietas foliis radicalibus lanceolatis longe petiolatis Jacq. t. 45." M. Battandier tells me that in Algeria *plantagineum* hybridises with *grandiflorum*. This is a matter for further

* The annulus of the tube is quite different; *plantagineum* belongs to De Coincy's sect. *Eleutherolepis*, *maritimum* oscillates between *Eleutherolepis* and *Gamolepis*.

investigation. So far I have not seen specimens that support this statement, but it can only be definitely confirmed in the field.

In the old herbaria I have found sundry specimens undoubtedly referable to *plantagineum*, but bearing strange determinations, the species having remained unrecognised until Linnæus's 'Mantissa' was published :—

(1) In Herb. Morison (at Oxford) labelled "*E. creticum latifolium rubrum* C. B. P. *E. creticum* Clus."

(2) Herb. Sloane, vol. 168, p. 12, among Banister's collection : "*E. creticum* P. Alpini."

(3) Herb. Sloane, vol. 321, p. 63, among Boerhaave's specimens are two pieces of *plantagineum* beside each other, labelled respectively "*Lycopsis* C. B. 255. *Altera anglica* Lob. 684. *Echii altera species* Dod. 904" and "*Anchusa Lusitanica non descripta ab expertissimo Dom. C.* . . . (illegible) *apud quem floruit anno* 1686 *in Viridario Lusitanico.*"

(4) Hort. Cliff. labelled by the first hand *E. folio asperrimo et verrucoso* and by the second hand *E. vulgare.*

(5) Hort. Cliff. labelled by the first hand *E. creticum latifolium rubrum* and by the second *E. creticum.*

(6) Hort. Cliff. labelled by the first hand *E. creticum angustifolium rubrum* (although identical with no. 5) and by the second *E. creticum.*

(7) Herb. Pallas, labelled *E. violaceum.*

(8) Herb. Helvet. in Hb. Dick, labelled by Solander *E. violaceum*, L.

(9) Herb. Miller (probably), labelled in Miller's hand "*E. creticum calycibus fructescentibus remotis* H. U. 35 ; *E. creticum latifolium rubrum* C. B. P." and by Solander *E. creticum.* (The smaller piece on this sheet, marked H. L. S. = Hortus Linnæi siccus, is not *plantagineum* but really *E. creticum*, herb. Linn.)

(10) Herb. Reg. Paris, 1827, originally labelled *E. maritimum ins. Stoechadum fl. Maximo* Tourn. Inst. 136 (which is represented in Hb. Tournef. No. 591 by a specimen of *E. grandiflorum*, Desf.), but by Miller *E. caule erecto hispido, foliis lin.-lanc. hispido-pilosis, semiamplexicaulibus, floribus spicatis terminalibus*, and by Solander *E. orientale.* This is the specimen which explains Smith's query on the Linnean specimen D. Of course, it has nothing to do with *E. orientale*, L.

All these specimens except the first are in the British Museum.

(V.) ECHIUM RUBRUM.

The three specimens J, K, L are in good preservation and quite typical of Jacquin's species. The mark on J indicates a plant sent by Gerber, who collected in South Russia in the area of *E. rubrum*. The unusual style, not deeply cloven into two filiform branches as in all other European species, but ending in a clubbed stigma, is conspicuous. The corollas still preserve the dark red colour, as of dry blood, that is peculiar to *E. rubrum*. The species was well known to Clusius, who has a good figure of it as *Echium rubro flore* in Rar. Stirp. Pann. p. 681 (1583) and in Hist. ii. p. 164 (1590), with a fair description, assigning as habitat the neighbourhood of Sopronium (Oedenburg) in Hungary, which is also Jacquin's *locus classicus*. Unfortunately, Clusius's name is quoted by Linnæus under *E. violaceum*, but *Echium rubro flore*, Ray Hist. p. 499, identical with Clusius's plant, is given as a synonym of *E. creticum*. To the confusion of mind underlying this double false reference may be attributed the absence of any determination by Linnæus of his three specimens.

(VI.) ECHIUM VIOLACEUM.

Echium violaceum, L. Mant. p. 42, has most frequently been misinterpreted, especially by British botanists, as a large-flowered form of *E. plantagineum*. Individuals of the latter species are often determined as *violaceum*; many such with large corollas, from the Atlantic islands, having been so labelled by C. B. Clarke in Herb. Kew. On the other hand, Grenier, in Fl. Fr. ii. p. 524, argued that Linnæus meant *E. rubrum*, Jacq., but the diagnosis and the specimen in the herbarium prove both suppositions to be wrong. Moris's statement in Fl. Sard. iii. p. 129 that *E. pustulatum*, Sibth. & Sm., was meant, "*E. violaceum* H. U. sic in Linnæi ! herbario, ramus absque foliis radicalibus, *Echium pustulatum* nostrum maxime refert. Ab *E. plantagineo* certe alienum," is nearer the mark, but I shall give reasons for thinking that the specimen is not true *E. pustulatum*, Sibth. & Sm.

Are we then to substitute *E. violaceum*, L., as the earlier name, for that of whatever species this specimen may really belong to? Certainly not; because even if the identity of the specimen were indisputable, the name *violaceum* is a confusion of the plant represented thereby with *E. rubrum*, Jacq., and ought therefore to be rejected as a *nomen confusum* in conformity with Art. 51, clause 4, of the international rules. To do otherwise would, in view of the continual and varying misuse of the name, only perpetuate error. It is therefore best to discard the name once and for all.

The confusion by Linnæus of *E. rubrum* with his herbarium plant from Hort. Ups. will become obvious if we analyse what he says in the 'Mantissa.' He begins (1) with a diagnosis: "Echium corollis stamina æquantibus;

tubo calycibus breviore." Then follow two synonyms: (2) *E. sylvestre hirsutum maculatum*, Bauh. Pin. 254, and (3) *E. rubro flore*, Clus. Hist. ii. p. 164. Then comes (4) "Habitat in Austria." And there follows an Obs. with five remarks: (5) "simillimum *E. vulgari* sed corolla violacea"; (6) "caulis magis diffusus"; (7) "stamina corolla non longiora, purpurea, tamen stylo albo piloso"; (8) "corollæ tubus longitudine fere calycis"; (9) "facies distincta." And (10) a statement that the plant described was grown in Hort. Ups. Of the above elements 2, 3, and 4 refer to *E. rubrum* and to *E. rubrum* only; the remaining seven apply to the herbarium specimen.

No. 2 (the first synonym), wrongly ascribed by Linnæus to C. Bauhin's 'Pinax,' p. 254 (1623), is not found there, but in his 'Phytopinax,' p. 490 (1596), as "*Echium sylvestre secundum hirsutum maculatum* = *E. rubro flore* Clus. Pann. p. 682." It is therefore identical with the second synonym, which is found in Clusius, Rar. Stirp. Pann. p. 681 (1583), and in his Hist. Pl. ii. p. 164 (1590), with an excellent figure that can represent nothing but *E. rubrum*, Jacq., and a fairly good account of the plant, stated to come from Sopronium (Oedenburg) in Hungary. The "habitat in Austria" therefore agrees with *E. rubrum*, but not with the specimen, which does not resemble any species found in Austria or Hungary *.

Nevertheless, it is impossible to identify the *violaceum* of Linnæus with *E. rubrum*, because: (1) the herbarium specimen is not *rubrum*; (2) the herbarium contains three excellent specimens of *E. rubrum*, though unnamed and unrecognised by Linnæus (see note 7 on specimens J, K, L); (3) *E. rubro flore*, Ray Hist. i. p. 499, which is identical with *E. rubro flore*, Clus., is not quoted here but under *E. creticum*, showing that Linnæus had no clear or consistent idea of *E. rubro flore*; (4) the diagnosis and the characters indicated in the Obs. are incompatible with *E. rubrum*. The specimen is not *rubrum*, because it has a bifid style and is unlike that species in every character. The identification with *E. plantagineum* or a large-flowered variety of that species is obviously incompatible with the synonyms and habitat assigned; it must have been based by those who adopted it on the descriptive elements, which at first sight might be thought applicable. But Linnæus tells us that he was describing the Hort. Ups. plant represented in the herbarium by our specimen, which is not *plantagineum* on account of the very different indumentum, and the pubescent corollas that also differ in texture and shape. The specimen is not the typical *E. pustulatum* of

* With regard to the *violaceum* of the German authors, it is to be noted that, as already remarked by Grenier, "l'*E. violaceum* des auteurs allemands pas plus que leur *plantagineum* ne croissent en Autriche, mais seulement en Istrie et en Dalmatie," which in the time of Linnæus did not form part of the Austrian territories, but were still subject-lands of Venice.

Sibthorp * from Sicily because the indumentum is different, being even more tubercular, but less hispid; this difference, however, may be due to cultivation; the calyces and bracts also look somewhat different.

Unfortunately the specimen in question only shows the upper part of a plant with a panicle about 30 cm. long by 10 cm. broad, the branches in the lower axils, whose flowers are still in bud, measuring 5–6 cm. The arrangement of the flowers almost recalls that of *E. rosulatum*, Lange, the cincinni being few-flowered and scattered and very obscurely scorpoid or hardly furled. The indumentum of the stem is dimorphous, but that of the leaves is peculiar and similar to cultivated examples of *rosulatum*. There is practically none of the soft pubescence which is present in so many species; all the hairs are bristles, larger or smaller, and the whole leaf very scabrous, not hispid, with regularly disposed setæ as in *plantagineum*, but with numerous minute tubercles scattered over both surfaces, some quite bald, some bearing inconspicuous bristly hairs. At intervals among these are larger tubercles occasionally crowned by stronger thick bristles, but in most cases these have been worn off or never developed, so that most of the pearly pustules, which are very conspicuous, look naked. The uppermost stem-leaves are lanceolate and pass insensibly into the lower bracts (which alone are visible) of the same shape. These are exceptionally long and foliaceous, equalling or exceeding the lower flowers. The calyx-segments are very long and acuminate, the corollas about 2 cm. long; rather less oblique than is usual in *E. pustulatum* and not so wide at the throat as in *plantagineum*, nor have they the peculiar thin texture of that species. They are pubescent all over, not glabrous with hairs along the nerves and ciliate as in *plantagineum*. They have dried blue with a paler pinkish throat. The style is hairy in its whole length and bifid to a depth of not more than 2 mm. The stamens are sub-exsert, *i. e.*, rather longer than the lower but shorter than the upper lobes of the corolla. Without dissection, which is not permissible, one cannot be sure whether the filaments are quite glabrous. I suspect that this garden plant originated from one of the *Echia* of the Spanish peninsula, but it is difficult to say from which.

In the old herbaria at the British Museum I have found sundry specimens more or less like that of Linnæus; all I think garden forms, in which cultivation has reduced the hairy coat, but not the pustules, so that the leaves sometimes look as though they were studded with pearls. Some of these show a peculiar lax inflorescence and diffuse habit, which may point to *E. rosulatum*, Lange, as their origin. Nor can we be sure that some may not be natural garden hybrids. None have the true radical tuft of leaves preserved:—

* See my note on the *Echia* of Sibthorp's herbarium, *suprà*, p. 386.

1. Herb. Sloane, vol. 306, p. 156, among Uvedale's Plantæ Rayanæ, as "*E. hispanicum verrucosum angustifolium*, Dni. Vaillant; an *E. foliis angustis villosis* Tourn." I have not detected hairs on the filaments of this specimen.
2. Herb. Sherard (at Oxford); from Dr. Dillenius as "*Echium perlatum* Vaill."
3. Hort. Cliff., labelled by the first hand "*E. foliis angustis et villosis* Tourn.," but by the second "*fruticosum*," which is then erased and altered to "*argenteum*," both the latter names belonging to South African species now referred to *Lobostemon*.
4. Herb. Gronov., labelled "*Echium foliis angustis et villosis* Tourn. 136. *Anchusa angustis villosis foliis*, Bocc. Mus. 2. 84, t. 78; *E. perlatum angustifolium Hispanicum quorundam*." This label is a transcript of Boerhaave, Ind. alt. Pl. p. 194 (1720).
5. Herb. Miller, labelled by him "*E. caule ramoso aspero, foliis calloso-verrucosis, staminibus corolla longioribus*; *Echium creticum* C. B. P.," then by Solander first "*orientale*" and afterwards "*angustifolium* Mill. Dict. no. 6."

Although the labels of the above specimens may point to *E. angustifolium*, Lam., they do not belong to that remarkable species, which has nothing to do with *angustifolium*, Mill. They are good instances of the wild shots of the old botanists at the names of their garden plants.

6. Hort. Chelsea, no. 2067 of 1763, labelled "*E. corollis stamine longioribus* L. Sp. Pl." (which is the diagnosis of *E. lusitanicum*) and "*E. amplissimo folio lusitanicum* Tourn."
7. Hort. Chelsea, labelled by Solander "*E. creticum*," on the same sheet as a piece of *plantagineum*, labelled by him "*orientale*."
8. Herb. Smith, labelled "*E. generense* Fairb.; *E. creticum*? Own garden, Marlboro' St. 1788."

Tournefort's herbarium unfortunately does not contain a specimen of his *E. foliis angustis et villosis*, nor have I been able to determine precisely the plants bearing that title in herb. Jussieu, no. 6621. No. 6622 "*E. Roris marini folio* Tourn. 136" is very like some of the old Mus. Brit. examples. But the difficulty of an exact determination of the *violaceum* of herb. Linn. is immaterial, for, whatever it be, it conflicts so absolutely with the diagnosis and synonyms that the name must certainly be abandoned.

(VII.) **ECHIUM VULGARE**, Sp. Pl. p. 139 (1753), had already been mentioned in Hort. Cliff. p. 43 (1737), as *E. caule simplici, foliis caulinis lanceolatis, floribus spicatis ex alis*," and again in Fl. Suec. p. 56 (1745), as found in Sweden, with the words of the diagnosis very slightly altered. In Hort.

Cliff. there is the observation, "varietates hujus fere tot quot individua," and the desperate suggestion that even the two following species, which are *creticum*, *rubrum*, *angustifolium* and *orientale*, may not be specifically different. The specimen is the upper part of a plant, with the inflorescence 24 cm. long by only 5 cm. broad, composed of over twenty simple, very scorpioid, axillary cincinni, none of which in flower exceed 25 mm. in length. The stamens all protrude beyond the longest part of the corolla, and have glabrous filaments. No habitat is marked, but the specimen is exactly the *E. vulgare* common in England.

To include in *E. vulgare*, L., the rather numerous forms which in southern Europe replace this plant of Scandinavia, England, and Central Europe, and differ from each other as much as from typical *vulgare*, is surely putting a great strain on the Linnean name. (See my paper on the *Echia* of Sibthorp's herbarium as to the relation of some of these forms to true *vulgare*.)

(VIII.) SPECIMEN G.

This is a young specimen of one of the Spanish forms of the *vulgare-pustulatum-gaditanum* group, but it is too scanty to determine more closely. It is a very small erect plant, not over 15·5 cm. high, with twofold indumentum and smallish blue pubescent corollas, about 2 cm. long, with style and the two longest stamens only protruding, equalling the upper corolla-lobes.

The mark, "152 *a*," seeing that this sheet is pinned to one marked "L. 152," indicates almost certainly that this specimen also was collected by Löfling. I have not been able to trace the phrase, "*E. montanum parvum flore magno*," in the old books, nor to ascertain what locality is meant by "in mont. Espartal.," although I find Cape Spartel on the African coast spelt "Espartel" in an old Spanish gazetteer. There is no evidence that Loefling ever visited the African side of the Strait of Gibraltar, but if this specimen really came from that region other possibilities as to its identity are opened up.

V.

THE *ECHIA* OF MILLER'S 'GARDENER'S DICTIONARY.'

Of the seven species of *Echium* described in Miller's eighth edition of 1768 all but the seventh give rise to troublesome questions. This innocent no. 7, *Echium fruticosum*, L., is a South African *Lobostemon*, *L. fruticosus*, Buek, of which no more need be said here. To take the other six in order: the first two are named by Miller *Echium anglicum* and *Echium vulgare*. The first, *E. anglicum*, of which he says "staminibus corollam æquantibus" is doubtless *E. vulgare*, L., var. *parviflorum*, St. Am., Fl. Agen. p. 82 (1821), the small-flowered pistillate form usually known as *E. Wierzbickii*, Haberl.,

Cat. Hort. Bot. Pest.* (1827), ex Rouy, Fl. Fr. x. p. 306, and in Reichb. Fl. Exc. p. 336 (1830). It has no claim to rank as a species, or even as a variety, being merely a sexual modification of *E. vulgare* occasionally found mixed with the type.† St. Amans states that both forms of corolla had been found on the same plant by the banks of the Garonne by M. Chaubard. The varying behaviour of seedlings from the pistillate form is discussed by Rouy in a footnote. Type-specimens of *E. Wierzbickii*, collected by Dr. Wierzbicki in the Banat, may be seen at Kew and at the British Museum. They are very exactly figured in Reichb. Fl. Germ. tab. 1298. fig. 3. Others with less extremely small corollas are at Kew from St. Amans's *locus classicus* on the Garonne, from Aurillac in Savoy, from Tal y Clawdd, near Ruabon, N. Wales, and elsewhere.

But Miller appears to have accidentally transposed the names *anglicum* and *vulgare*. He was, as usual, describing under no. 1 a garden plant—one not known to him as a British native, for he says "it grows naturally in Germany and Austria, from whence I received the seeds." The only specimen in his herbarium marked "*anglicum*" is precisely the common *E. vulgare*, L., with protruding stamens, which therefore represents his no. 2, not this no. 1. Moreover, the name *anglicum* is derived from Lobel's *Lycopsis anglica*, which Miller quotes as a synonym of his no. 2, whereas he cites *E. vulgare*, C. B. P., for no. 1, though it is quoted by Linnæus for *E. vulgare*. Hudson, Fl. Angl. pp. 69, 70 (1762), had already used the names *anglicum* and *vulgare*, but in an opposite sense from Miller, for his *vulgare* is defined "caule simplici erecto, foliis caulinis lanceolatis hispidis, floribus spicatis lateralibus, staminibus corollam æquantibus," which is Miller's diagnosis of his *anglicum*, whilst Hudson uses the name *anglicum* for the common British plant, and defines it (quoting *Lycopsis anglica Lobelii*) as "caule simplici erecto, foliis lanceolato-linearibus hispidis, floribus spicatis lateralibus, staminibus corolla longioribus," this being the phrase which Miller applies to his *E. vulgare*. Hudson professes to be quoting both these phrases from Mill. Dict. Hort. edit. 6, which is not in accordance with fact, for Miller first used them in his seventh edition of 1759. They do not occur in the sixth edition of 1752, where *Echium vulgare* alone is named, with no allusion to the length of the stamens. In ed. 2, p. 83 (1778), Hudson reduces *E. anglicum* to *E. vulgare* var. *anglicum*.

Miller's second species, *E. vulgare*, is precisely *E. vulgare*, L., whose diagnostic phrase, which originally appeared in Hort. Cliff. p. 45 (1737), he copies with the addition of the words "staminibus corolla longioribus." These words and his statement that "this second sort grows naturally upon

* I have not been able to see a copy of this work, and Rouy does not mention the page.

† For *E. Wierzbickii*, see Coincy in Bull. Herb. Boiss. ser. 2, i. pp. 789-792.

chalky lands in most parts of England" establish the identity. We therefore get the following synonymy :—

(1) *Echium anglicum*, Mill. = *E. vulgare*, Huds. ed. 1 = *E. vulgare*, L., var. *parviflorum*, St. Am.* = *E. Wierzbickii*, Haberl., and

(2) *Echium vulgare*, Mill. = *E. vulgare*, L. = *E. anglicum*, Huds. ed. 1 = *E. vulgare* var. *anglicum*, Huds. ed. 2. Bauhin's synonym should, of course, belong to Miller's *E. vulgare*, not to his *E. anglicum*, where for some obscure reason he has wrongly placed it.

Here the matter might end were it not for the unfortunate introduction, as a synonym, both by Miller and by Hudson, of Lobel's *Lycopsis anglica* or *Lycopsis altera anglica*. This is no doubt what led to Linnæus assigning Anglia as a habitat of *Echium italicum*, to which species he very rightly, in Sp. Pl., transferred Lobel's name as var. *β*. To trace the origin of the error as to Lobel's plant, and the confusion to which it has given rise, involves a long digression.

Lobel, in his 'Stirpium Adversaria nova,' p. 249 (1570), describes a plant under the name of *Lycopsis, vel Lycapsis degener Anchusa, Æginetæ. Mathioli Cynoglossum.* He tells us in very awkward Latin that it was first shown to him by Assatius, not far from the shore at Frontignan, and that he afterwards raised it from seed at London in England. He also states that it has no real similarity to *Anchusa*, except in the colour of the root, the hispid stem and leaves, and the tangled hairiness of the flowers; and that it has the flowers of *Echium fimbriatum* †, of a dilute purple colour, with slender stamens. Now the only *Echium* growing in the Montpellier neighbourhood to which this account could apply is *E. pyrenaicum.* Lobel's plant is figured in his Stirp. Hist. p. 312 (1576), as "*Lycopsis altera anglica* Advers. p. 249 *perperam Cynoglossum Matthioli*" alongside of "*Echium sive Buglossum silvestre.*" The figure in question certainly represents *Echium pyrenaicum.* The corollas are clearly intended for those of either *E. italicum* or *E. pyrenaicum*, but the broad pyramidal branching is more like *pyrenaicum.* The corollas especially, as well as the ramification, forbid the identification with *E. plantagineum*, which was made by C. Bauhin and by Ray, and for other reasons might be tempting.

The same pair of figures recur in the 'Kruydtboeck,' p. 684 (1581), and in Ic. Stirp. p. 579, in both editions of 1581 and 1591, and are again found in Dodoens, Stirp. Hist. p. 620 (1583), under the names of *Echium* and *Echii altera species*, and in Gerard, Hist. Pl. p. 802 (1633), as *Echium vulgare* and *Lycopsis anglica.* Thus *Echii altera species*, Dod., is identical with

* Wrongly attributed to Schur, Enum. Pl. Trans. p. 470, which is much later (1866).

† I have not ascertained what plant he alludes to as *E. fimbriatum.*

Lycopsis altera anglica, Lob., which, be it noted, does not mean "another English Lycopsis," but "another Lycopsis, the English one." An unfortunate expression, for that word "*Anglica*," which only meant that Lobel had grown the plant in England, misled the later authors [*e. g.*, Parkinson, Theatr. p. 518 (1640)], who wrongly assumed that *Lycopsis anglica* must be a native English plant. If they had read a few lines farther they would have found Lobel saying: " Hæc ab ea quæ hic in Anglia via quæ Bathonia et Bristolia Londinum ducit per messes læta et multa hilari videtur aspectu, floribus tantum differt; quos non secus foliorum et alarum interstitia, sed in summis caulibus saturatiore purpureo, Anchusæ majoris. Ut prior (*sc.* Anchusa lignosior angustifolia) subrubra linet et nonnihil rubelli affricat digitis," meaning that his *Lycopsis altera Anglica* is not the common English Viper's Bugloss, which he had admired in the fields near the Bath Road.

Caspar Bauhin, in his 'Pinax' (1623), enumerates on p. 254 eleven plants under the name of *Echium* (not all belonging to the modern genus), including *E. vulgare* as no. 2. Then on p. 255 he has two species of *Lycopsis*, the second of which, *Lycopsis ægyptiaca*, does not concern us, but to the first, which is "*Lycopsis*" simply, he appends a long list of synonyms, and among them are *Echii altera species*, Dod., *Lycopsis vel Lycapsis degener Anchusa Æginetæ*, Ad., and *Lycopsis altera Anglica*, Lob. It is therefore certain that C. Bauhin considered Lobel's plant identical with his own "*Lycopsis*." But his remark at the end of the list of synonyms lets the cat out of the bag, for it is only intelligible of *E. plantagineum* and cannot apply to *E. pyrenaicum*. It is "*Aliquando caule caret*; *Monspeliaca flore est dilute purpureo*; *anglica saturatioris est purpuræ*." Now *E. plantagineum* often occurs in a dwarf form, and the colour of the corollas varies just as stated by C. B., sometimes a pale reddish purple predominating, particularly in the Ionian Islands (*cf.* Fl. Gr. tab. 179), sometimes a full purplish blue which dries blue. We must therefore bear in mind that *Lycopsis anglica*, Lob., is *E. pyrenaicum*, but *Lycopsis* or *Lycopsis anglica*, C. B. P., is *Echium plantagineum* *.

J. Bauhin, Hist. Pl. iii. p. 586 (1561), absurdly says of Lobel's two figures, "*ambæ nostrum Echium vulgare referunt*," which they do not. His own two figures are different. They represent *E. vulgare* and his *E. albo flore majus*, which is *E. italicum*.

Merrett, Pinax Rer. Nat. Brit. p. 34 (1666), following Parkinson, claims *Lycopsis anglica* (of Gerard and therefore of Lobel) as a British plant. He speaks of *E. vulgare*, Ger., "in muris et locis siccis," and of "*Echium alterum* sive *Lycopsis anglica* as growing "cum priore," so he regarded this as a companion form of *Echium*. Richardson (see below) understood him to mean var. *parviflorum*.

* An examination of Bauhin's herbarium at Bale would be desirable to confirm the above.

Ray, Syn. Meth. Stirp. Brit. p. 75 (1690), only quotes *E. vulgare* for England, "nimis etiam frequens," but in the addenda at p. 238 there occurs among the plants observed in Jersey by Mr. Sherard, "*Lycopsis* C. B. *Echii altera species* Dod. p. 680, cujus ic. hanc nostram bene repræsentat. In the sandy grounds near St. Hilary plentifully." This means that Ray understood Bauhin's *Lycopsis* to be the species subsequently known as *E. plantagineum*, for the Jersey plant is well known to be that kind. It is still abundant at St. Helier's and elsewhere in the island, see Lester-Garland, Fl. Jersey, p. 126 (1903). Specimens from Sherard's *locus classicus* can be seen in Herb. Mus. Brit. and are exactly *E. plantagineum*, which is figured in E. B. tab. 2798 from the Jersey plant under the name of *E. violaceum*. But the remark about Dodoens's figure is strange from Ray, who had travelled where *E. plantagineum* is plentiful. Apparently he was not so well acquainted with *E. pyrenaicum*, though he had seen *E. italicum* in several parts of Italy. In the second edition of 1696, p. 119, he speaks of *Lycopsis*, C. B., and *Lycopsis anglica*, Lob., as of two different species, the former (with *Echii altera species* again wrongly brought in) growing in the isle of Jersey and therefore *plantagineum*; but of the latter he says "Lobel mentions another sort which he calls *Lycopsis anglica*, to be found plentifully among the corn on the way between Bristol and London, which no man since him hath been able to discover; so that I conclude what he observed there was nothing but the common *Echium*." This conclusion is right, but Ray misrepresents Lobel, perhaps from memory, as saying just the contrary of what he really had said.

Then in ed. 3, p. 227 (1724), three species are definitely set up, intended for *E. vulgare, E. plantagineum* (from Jersey only), and *E. vulgare* var. *parviflorum*, and referred to respectively as follows: 1. *E. vulgare*, J. B., iii. 586, C. B. P., 254. 2. *Lycopsis*, C. B. P., repeating all that had been said in ed. 2 as to this plant occurring in Jersey. 3. *Echium alterum* sive *Lycopsis altera*, Merrett. "We have two to be met with in the North as well as in the South; the *alterum* differs from the *vulgare*, J. B., chiefly in the smallness of the flower and being thicker set in the spike. 'Tis probable this may be *Lycopsis anglica Lobelii*." This observation is due to Dr. Richardson, many of whose notes were embodied by Dillenius in this 3rd edition.

Meanwhile, in 1699, Morison, Hist. Ox. iii. p. 441, had described *Echium plantagineum* as his no. 6 under a new name as follows: "*Echium ramosius annuum flore suave rubente*, Nobis. *Lycopsis* C. B. P. *Echii altera species* Dod. Hæc fortasse est eadem planta, quæ a Lobelio in 'Adversariis,' p. 249, memoratur; et e seminibus in Insula Cæsarea vulgo Jersie a cl. Botanico D. D. Sherard collecta, nobis orta est." He therefore did not distinguish the *Lycopsis* of Lobel from that of Bauhin.

We may now turn to the old herbaria. That of Sherard, which by the

kindness of Mr. Druce I have inspected, contains no plant from Jersey; his only example of *E. plantagineum* was sent by Trionfetti and is unnamed. That of Dillenius, besides two pieces labelled *vulgare*, has one labelled "*Lycopsis* C. B. Pin. In agris Blackheath." This, though thought by Sir J. E. Smith to be *italicum* is nothing but *vulgare*, as Mr. Druce has already stated in 'The Herbaria of Dillenius,' p. 75. But in Morison's herbarium there is a specimen of his *Echium ramosum annuum flore suave rubente*, which should be the plant raised from seeds collected by Sherard in Jersey, and indeed is referred to *plantagineum* by Vines and Druce in their account of the Morisonian Herbarium. Unfortunately the specimen on closer examination turns out not to be *plantagineum*, as is proved by the corollas being pubescent all over and by the indumentum. But the next specimen, labelled originally "*Echium creticum latifolium rubrum* C. B. P.," and accepted by Vines and Druce as *E. creticum*, L., is precisely *E. plantagineum*. It looks as if there had been some interchange of the specimens or their labels, and the second specimen was really the one raised from the Jersey seeds.

The volumes of the Sloane herbarium at the British Museum are instructive. In vol. 121, containing the Plantæ Britannicæ of the Rev. Adam Buddle (1660–1715), at p. 6, there is a scrap of *E. plantagineum*, labelled "*Echii altera species*, Dod.; *Lycopsis* C. B.," and then, alongside of each other, two very similar spikes of *E. vulgare*; one the ordinary form, labelled "*Echium flore magno*. This I take to be the *Lycopsis anglica*, Lob. Ger. etc., though 'tis very common"; the other var. *parviflorum* labelled "*Echium flore parvo*. This I take to be the *Echium vulgare* C. B. etc., though very scarce." Thus we have Ray's three kinds on the sheet, and we also have the first suggestion of the identification, afterwards adopted by Miller, of C. Bauhin's *vulgare* with the small-flowered form.

In vol. 151, p. 177, among Petiver's plants, are four specimens of which two are *E. vulgare*; the third marked "*Echium anglicum flore minore, stylo tantum exserto*" is var. *parviflorum*, and the fourth, although labelled "*E. ramosius flore suaveolente* H. Ox.," is merely the white-flowered form of *vulgare*. Then in vol. 321, p. 63, among Boerhaave's specimens, is a piece of *E. plantagineum* labelled "*Lycopsis* C. B.; *Altera anglica*, Lob.; *Echii altera species*. Dod."

To sum up the pre-Linnean position:

1. *Lycopsis altera anglica* Lobel = *Echium pyrenaicum* grown by him in London.
2. *Echii altera species*, Dod., is identical with Lobel's *Lycopsis altera anglica*.
3. *Lycopsis*, C. B. P., is *Echium plantagineum*, of which he knew the pink-purple and the purple-blue variations.

4. Parkinson in 1640 and Merrett in 1666 first apply Lobel's name, probably known to them through Gerard, to an English form of *vulgare*.
5. This idea is taken up by Richardson in Ray, who assigns Lobel's name to the pistillate form of *vulgare* from northern England, forgetting that the figure shows protruded stamens and a totally different habit, and refers *Lycopsis*, C. B. P., to the Jersey plant, *i. e.*, to *E. plantagineum*.
6. Morison refers *Lycopsis*, C. B. P., to the Jersey plant and suggests that Lobel's may be the same.
7. Boerhaave refers Lobel's, C. Bauhin's, and Dodoens's names all to *E. plantagineum*.

So far, the identity of Lobel's plant with some form of *E. italicum* does not seem to have been suspected. But Linnæus, Sp. Pl. p. 139 (1753), quotes *Lycopsis*, Bauh. Pin., as var. *β* of *E. italicum*, showing that he recognised the true significance of Lobel's figure, but misunderstood Bauhin's *Lycopsis*. In ed. 2, p. 200 (1762), he adds some characters to distinguish var. *β* from typical *italicum*, which do not alter the position. Only, as the English authors had quoted both Bauhin's and Lobel's names for British plants, he not unnaturally fell into the trap and supposing *italicum* in some form to be British, quotes for it "Anglia." In the same year, 1762, Hudson reproduces the theory that Lobel's name is one of the English forms of *vulgare*, for which he now must coin a binomial name, and therefore creates *E. anglicum*, though he oddly applies that name to the common form of *E. vulgare* and the name *vulgare* to the rare pistillate form, just as Buddle had done before him. He also identified *Lycopsis*, C. B. P., with the Jersey plant, but finding it already quoted by Linnæus for *E. italicum*, thinks it necessary to call it *italicum*, using the Linnean diagnosis of this, which is inapplicable to the Jersey *plantagineum*.

Linnæus saw Hudson's work in time to insert a reference in the Appendix of Sp. Pl. ed. 2, p. 1678, where he treats Hudson's *E. anglicum* as synonymous with his own *E. italicum*, and Hudson's *E. italicum* as equivalent to his *E. italicum β*, which afterwards became *E. pyrenaicum* in the 'Mantissa.' These disastrous identifications are based entirely, as so often in Linnæus's work, on the old synonyms quoted by Hudson. Thus he, Miller, and Hudson between them introduced a fresh error, that *E. italicum* in some form is a native both of England and of Jersey. This will be dealt with under Miller's third species.

Miller's third species is ECHIUM ITALICUM *corollis vix calycem excedentibus, margine villosis*. Hort. Upsal. 35; *Echium majus et asperius flore albo*, C. B. P., 255. This grows naturally in the south of France, in Italy, and in

the Isle of Jersey. It has never been doubted that this is *E. italicum*, L., Sp. Pl. p. 139 (1753), *exclusa* var. *β*. The erroneous account of the length of the corollas is copied from Linnæus, who repeated it from his Hort. Ups. in Sp. Pl. ed. 1, but not in ed. 2, where the first really intelligible account of *E. italicum* occurs.

There is only one sheet of *E. italicum* in Herb. Miller. It agrees perfectly with the specimen in the Linnean herbarium, which is precisely *E. altissimum*, Jacq. There is no writing on the sheet in Miller's hand, the name *italicum* being written in pencil by Solander. There is no other Chelsea Garden specimen of *italicum*; one bearing no. 2716 and the words "*E. italicum* 1776," with a penstroke through them, is *E. plantagineum*. It cannot have been labelled *italicum* by Miller, for he died in 1771.

But Jersey must be excluded from the habitat. Its supposed presence there is due partly to reliance on the unfortunate "*Lycopsis*" muddle. The false argument was this: *Lycopsis* has been found plentifully in Jersey by Sherard; Linnæus says *Lycopsis* is *italicum* and Hudson also calls the Jersey plant *italicum*; therefore *italicum* grows in Jersey. But the error has been kept alive owing to confusion between the white-flowered form of *vulgare* and *italicum*. Although *vulgare* is not quoted for Jersey by Lester-Garland, he says it is frequent in Herm and common in Alderney, and it looks as if the white form had been found in Jersey in the past, though it cannot be claimed with certainty. In Herb. Sloane, vol. 151, p. 177, there is an example of white *vulgare* among Petiver's plants bearing his label: "*Echium ramosius flore suaveolente*, H. Ox.; *altera species*, Dod.; *Lycopsis*, C. B., *Anglica*, Ger.; *altera Anglica*, Lob. Wall Bugloss in the Isle of Jersey." The plant is certainly *vulgare fl. albo*, but it is possible that the last words of the label may not mean that this individual came from the island.

Echium italicum is professedly figured in E. B. tab. 2081 as "a native of Jersey, for specimens of which from Chelsea Garden we are obliged to Mr. Fairbairn." Probably the seeds of the Chelsea Garden plant had not really come from Jersey. Sowerby's original drawing at the British Museum only says "Chelsea Garden," and does not mention Jersey. The drawing seems to be a compromise between *E. italicum* and white-flowered *E. vulgare*, of which an explanation is suggested by a sheet in Sowerby's herbarium at Mus. Brit., where there are two specimens, both referred to E. B. tab. 2081, but while that on the left is true *italicum*, the one on the right is white *vulgare*. Between the two is a piece, in bud only, from J. Dickson's 'Hortus Siccus Britannicus,' 1793–1799, marked "*Echium italicum*, Jersey." As far as can be judged in so early a stage, this really is *E. italicum*, but did it come from Jersey? or is it a garden plant from seeds wrongly supposed to come from that island? If really from Jersey, *E. italicum* must have existed there at that time as an escape and since died out.

White-flowered *E. vulgare* occurs now and then in England, but Mr. Druce informs me that he knows no case of *E. italicum* being found except as a casual at Ware in Herts, where foreign poultry food is brought, and at Cothill in Berks. He has kindly allowed me to examine his specimens from both localities. Neither is true *italicum*. They are a very lax form of *E. pyrenaicum*, identical with Lapeyrouse's authentic specimens of his *E. pyramidale*.

Miller's fourth species is "ECHIUM LUSITANICUM *corollis stamine longioribus*, L. Sp. 200 ; *E. amplissimo folio, lusitanicum* Tourn. Inst. 135."

"It grows naturally in Portugal and Spain ; the lower leaves often are more than a foot long and two inches broad in the middle, gradually lessening to both ends, these are covered with soft hairs. The stalks grow two feet high ; the flowers are in short spikes coming from the side of the stalks; the petals of these are longer than the stamina."

This admirable description can apply to nothing but *Echium Broteri*, Sampaio ex Coutinho, as Boragineas de Portugal in Bol. Soc. Brot. xxi. p. 111 (1905), and in Cout. Fl. Port. p. 499=*E. lusitanicum*, L. (saltem herb.)=*E. italicum*, Brot. Fl. Lus. i. p. 290, and Hfg. et Lk. Fl. Port. i. p. 185, non L. The account of the leaves is quite conclusive. They are unlike those of any other species.

Miller cannot possibly have meant *E. plantagineum*, to which for some inscrutable reason his *E. lusitanicum* is referred, along with *E. amplissimo folio lusitanicum*, Tourn., by Link on p. 186. De Candolle, Prodr. x. pp. 20 & 22, made the confusion worse by accepting this false identification for Miller's *E. lusitanicum*, but not for Tournefort's synonym nor for *E. lusitanicum*, L.

For an explanation of the often-repeated false statement that the Linnean herbarium contains no example of *E. lusitanicum*, and for a justification of the identification of *E. lusitanicum*, L., with *E. Broteri*, Samp., I must refer to my notes on the *Echia* of Linnæus. The only ground for doubting the identity of Miller's, or indeed of Linnæus's, *lusitanicum* with *E. Broteri* is the account which Linnæus and Miller both give of the relative length of stamens and corolla, which certainly is not true of *E. Broteri*, but it would also be untrue of any other Portuguese species to which Miller's name could be supposed to apply.

It looks as if Miller had simply copied Linnæus's statement without thought. I can only suppose that Linnæus himself made a mistake. There is an analogous misdescription of the length of the corollas of *E. italicum* in Sp. Pl. ed. 1, where these are quite wrongly said to be "vix calycem excedentes."

There exists no specimen of *E. lusitanicum* marked "Herb. Miller," but there is a fine one from Chelsea Garden marked, though in pencil, by

Solander "*italicum*" and "*Echium lusitanicum* L. M." This is precisely *E. Broteri*, of which there are two other old specimens in Herb. Sloane, both from Petiver's collections. These are mentioned in detail in my notes on the *Echia* of Linnæus.

Miller's fifth *Echium* is "ECHIUM CRETICUM *calycibus fructescentibus distantibus, caule procumbente*, Linn. Hort. Upsal. 35; *Echium Creticum latifolium rubrum* C. B. P. 254. The fifth sort grows naturally in Crete; this hath trailing hairy stalks, which grow about a foot long, and put out several side branches, garnished with hairy spear-shaped leaves about three inches long, and three-quarters of an inch broad, sitting close to the stalks. The flowers come out on slender spikes upon long foot-stalks which come from the wings of the leaves; they are large, of a reddish-purple colour, which turns to a fine blue when they are dried; these stand at a distance from each other on the spike. It is an annual plant which flowers in July and decays in autumn."

Echium creticum, L., is a mixture of two very different species, which Clusius had distinguished, one being *E. creticum angustifolium rubrum*, C. B. P., which is Miller's sixth sort; the other *E. creticum latifolium rubrum*, C. B. P., which is represented by the specimen in Herb. Linn.

This is a cultivated plant, which cannot have been derived from any Cretan kind, but is obviously a garden modification of *E. grandiflorum*, Desf. (See my notes on the *Echia* of Linnæus.)

According to the synonymy, Miller's *E. creticum* should be the *E. creticum* of Herb. Linn. His statement that it grows naturally in Crete is a mere parrot echo of what he had read. Clusius himself was uncertain about the supposed Cretan origin. But, although the synonyms point to *E. creticum*, Linn. herb., I fear that Miller mixed up with it *E. plantagineum*, which is plentiful, though misnamed, in the old herbaria and not otherwise referred to in his dictionary. Indeed, his English description is more than suspiciously like *E. plantagineum*. The spear-shaped leaves he mentions would exclude that species if he were speaking of radical leaves, but he means the stem-leaves. The purplish flowers of *plantagineum* often—not always—turn a "fine blue" when dried; those of *E. creticum*, Linn. Herb., do not.

The only Cretan kind, other than *plantagineum*, that could be thought of for a moment is *E. parviflorum*, Moench, especially in its luxuriant form, var. *erectum*, DC. This, indeed, is the *E. creticum* of the 'Flora Græca,' but not of Linnæus. It is, however, absolutely excluded by what Miller says of the flowers and by the reference to the synonyms.

The specimens in the old herbaria, of which a fuller account will be found in my notes on the *Echia* of Linnæus, confirm the suspicion of a muddle. There are none at the British Museum marked "Herb. Miller." One from

Chelsea Garden in 1749, no. 1367, labelled "*E. creticum angustifolium rubrum,* C. B. P.," where "*angustifolium*" obviously is a slip of the pen for *latifolium*, is the *E. creticum* of Herb. Linn., but another, labelled by Solander "*E. creticum*," is a variety of *E. pustulatum*, S. & S., or one of the allied Mediterranean forms. There is also a sheet with no indication of where its contents grew, labelled in Miller's handwriting "*E. calycibus fructescentibus* etc., H. U. 35 ; *E. creticum latifolium rubrum*" and by Solander "*E. creticum*." Unfortunately, it contains two pieces belonging to different species, the smaller being really *E. creticum*, Herb. Linn., but the larger *E. plantagineum*.

Therefore I think we must consider *E. creticum*, Mill., to be a *nomen confusum*. This is immaterial, as it does not affect the interpretation of *E. creticum*, L.

Miller's sixth sort is ECHIUM ANGUSTIFOLIUM *caule ramoso, aspero, foliis calloso-verrucosis, staminibus corolla longioribus. E. creticum angustifolium rubrum*, C. B. P., 254. "This sixth sort hath branching stalks which grow a foot and a half long, declining toward the ground ; they are covered with stinging hairs ; the leaves are four inches long and not more than half an inch broad ; they are pretty much warted and are hairy. The flowers grow in loose spikes from the side of the stalks, and also at the end of the branches ; they are of a reddish-purple colour, but not so large as those of the former sort, and the stamina of these are longer than the petal. This is also an annual plant which grows naturally in Crete."

From the excellent description and from the synonym this is certainly *Echium hispidum*, Sibth. et Sm., Fl. Gr. Prodr. i. p. 125 (1806), Fl. Gr. tab. 181 = *E. elegans*, Lehm. Asperif. p. 459 (1818) = *E. Sibthorpii*, Roem. et Sch. Syst. iv. p. 26 (1819). Lehmann's and Roemer's names were only created to replace that of Sibthorp, owing to the existence of an earlier homonym, *E. hispidum*, Thunb., a Cape plant, now referred to the genus *Lobostemon*. We must boldly adopt Miller's name of *angustifolium*, if the rule of priority is to be adhered to. To such a course three objections might be raised. Firstly, that it would cause two changes in accepted nomenclature, for, as *E. angustifolium*, Lam., would have to give way to *E. angustifolium*, Mill., the name of that species too would have to be changed. Secondly, Miller calls his plant annual, whereas *elegans* is stated by Halácsy in Consp. Fl. Gr. ii. p. 338, to be perennial. Such a mistake in this genus is very easy to make, unless the writer is well acquainted with the plant in its native haunts. Moreover, many Mediterranean coast perennials will not survive the damp of English autumns, even if they resist the frost of winter, and have to be treated as annuals in English gardens, where alone Miller knew his plants. I think we may fairly brush aside this objection.

Thirdly, the presence of an inconvenient specimen in Herb. Miller with

a ticket in his own hand: "*E. caule ramoso aspero, foliis calloso-verrucosis, staminibus corollis longioribus*," which is the diagnosis of *angustifolium* and "*E. creticum angustifolium rubrum* C. B. P.," to which Solander has added in pencil "*E. orientale*" and "*angustifolium* Mill. Dict. no. 6." Unfortunately, the plant is not *creticum angustifolium rubrum* and does not agree with Miller's description. It is referable to *E. pustulatum*, which was often confused in early times with *E. hispidum*, e. g., by Smith himself. (See my note on the *Echia* of Herb. Sibthorp, p. 386.) We must not be governed by the specimen and ignore the excellent description, especially when the specimen is a garden plant. It is common to find specimens in the old herbaria which do not agree with the species described. The case is different from that of *E. maritimum*, Willd., which is represented in that author's herbarium by a single piece of *E. plantagineum*, for Willdenow has told us that he never saw but one example of his *maritimum*. See de Coincy in Morot's Journ. Bot. xiv. p. 163, who consequently alters the name *maritimum* to *confusum*, a proceeding in which Rouy has refused to follow him. I may quote the apposite remarks of Bonnet in his account of Lamarck's herbarium, Journ. Bot. xvi. p. 137:—"On connait les incohérences de l'herbier de Linné et les confusions de Willdenow . . . . un échantillon d'herbier ne doit servir à infirmer une description publiée que s'il n'existe aucun doute sur son authenticité; la description originale, même incomplète ou défectueuse reste entière, tandis que l'échantillon d'herbier est trop souvent soumis à des causes qui en altèrent l'intégrité et l'authenticité." Now, though we know that Miller wrote that ticket, we do not know who at some later time gummed it to the sheet where we now find it.

On the whole, I think we should not be deterred by these three obstacles from reviving the neglected name, which seems to have been noticed by no one but Poiret in Dict. Encl. viii. p. 671, where he quotes it as var. *b* of *E. creticum*, L., and equivalent to *E. creticum angustifolium rubrum*, Tourn., which is known to be *E. hispidum*. Poiret is, of course, wrong in assigning as synonyms of *angustifolium*, Mill., Lamarck's *angustifolium* and Barrelier, ic. 1011, which represents Lamarck's plant.

Plant-Distribution from the Standpoint of an Idealist.

By H. B. GUPPY, M.B., F.L.S.

[Read 7th February, 1918.]

THE most interesting and at the same time the most mysterious features of plant-distribution centre around the rise of the great families. These ancient plant-groups belong so much to an era of other things, other ways, and other conditions, that the employment of such terms as "genera" and "species" in connection with their origin seems to be almost meaningless. All the influences that we see normally at work around us now could only relate to the differentiation of the family-types into genera and species; and any theory that on such grounds endeavours to apply the present to the past in deciphering their origin would apparently be attempting an impossible task. One ventures to think that only the hypothesis that finds its guide to the past in the abnormalities of the present could be of service here. This would seem to place the pre-differentiation era, the age that witnessed the rise of the great families, outside the field of the Natural Selection theory, and in default of its aid to cause us to look to the Mutation hypothesis for guidance. Yet, although Darwin came to reject the "sport," the original scope of his theory was large enough to admit it; and it may be, as the writer holds, that the antithesis between the two theories is more apparent than real. Yet the Mutation hypothesis was conceived in the spirit of Darwinism, was framed on Darwinian lines, and was formulated in Darwinian language; and it is not easy to understand how the two theories were allowed to acquire the appearance of being mutually exclusive. There is room for both within the boundaries of the theory of Natural Selection as Darwin first conceived it; and there is work for both schools in its extension, its improvement, and its emendation. Whilst the Mutationist would find a fruitful field for his labours in the era of the rise of the great family-types, the Darwinian evolutionist would be occupied with their subsequent differentiation into tribes, genera, and species.

The rise of the great families and the lesson of the Compositæ and the Gentians.—Two papers of great importance from this standpoint to the student of plant-distribution were published in the 'Journal of the Linnean Society' in 1873 and 1888, the first by Bentham on the Compositæ, the second by Huxley on the Gentians. They are important because, in dealing with the beginnings of the distribution of these two families, they ask the same questions and raise the same issues; and it is needless to add that, although in one case the methods employed were those of a great botanist and in the other those of a great zoologist, they bear in each case the impress of a master hand. Those interested in the subject will remember

that two years before the publication of his paper Huxley had outlined his views in two letters to Hooker, letters which are given in the 2nd edition of his 'Life and Letters,' by his son (ii. 465–6, 1903).

It is proposed to commence this paper with a comparison of the views held by these investigators respecting the early history of the distribution of the two families concerned. Both are agreed as to the original wide distribution of the primitive forms over the world, and both credit them with ignoring the great physical features of the globe, as at present displayed. Broad oceans, great deserts, and lofty mountain-ranges are all out of the reckoning in the respective discussions relating to the spread of these two families over the earth. Bentham holds to a very wide dispersion of the original stock of the Compositæ over the world when the physical configuration was very different from what it is in our day. Huxley speaks of a "primitively continuous area of distribution," and leaves the matter there. With reference to the state of differentiation of the original stock when it conquered the earth, Bentham holds that the Old and the New Worlds possessed the family at the earliest recognizable stage. Huxley hypothecated a widely spread primitive type that subsequently differentiated over the globe. Both, in imputing a high antiquity to the respective stocks, knowingly disregarded the lack of geological evidence, the one considering that the Compositæ dated back to an early geological period, the other holding that even the more specialized and consequently the more recent of the Gentians might have lived in the Cretaceous epoch. But Huxley went even beyond this when he assumed that the "Ur-Gentian" might be carried back "almost as much farther as probabilities permit us to carry the existence of flowering plants."

For neither Bentham nor Huxley were the main features of the distribution of these two families concerned with means of dispersal. Huxley makes but little appeal to them and Bentham discredits their efficacy. Bentham begins with a family already universally distributed, although he implies an original centre of dispersion. Huxley would have nothing to do with any such centres, and his plain words on this subject ought never to be forgotten by the student of distribution. All such notions were excluded for him in a type that followed the principle of *the simpler and older the type the greater its range.*—"The facts of distribution of the Gentianeæ are (he writes) not to be accounted for by migration from any centre of diffusion to which locality can be assigned in the present condition of the world." The problem was for him essentially a matter of the local modification of plants at different points of a "primitively continuous" area. Both Bentham and Huxley are at one in their conclusion that the main features of the distribution of these two families were determined in ages geologically remote ; and neither's view of the early stages in the history of their distribution leaves any room for an appeal to centres of

dispersion. If behind the facts of distribution lies the cardinal principle that the farther we trace a type back the more generalized are its characters and the wider its range, the question of its original home is obviously not raised.

What, we may ask, was the bearing of these views on general taxonomic principles? Bentham was dealing with a world-ranging family holding about a tenth of the total known number of Angiosperms and displaying relatively few of the difficulties presented by small families with restricted distribution. He followed orthodox lines and the results were not disquieting to the systematist, although, if he had pushed his conclusions home, a clash with prevailing practice would have happened. With Huxley it was very different. He was concerned with a much smaller family, one less widely distributed and displaying a preference for mountainous regions. To it he applied the same method of postulating a wide-ranging but little differentiated primitive type, and in so doing he raised many of the difficulties presented by the smaller families. But his method, as he perceived, considerably upset the accepted grouping of the Gentians, and in his enthusiasm in its advocacy he contended that "a revision of Taxonomy and Distribution from the point of view of the Evolution doctrine will hardly fail to revolutionise both." But the curious point is that as far as the early stages in the history of the Gentians are concerned the method advocated by Huxley was not Darwinism, as then conceived. It was pure Differentiation. With Bentham also, although clinging to the idea of a centre of dispersion, or of a home, for the Compositæ, he began with a world-ranging but slightly differentiated primitive type, and like Huxley with the Gentians he allowed it to work out its own lines of differentiation in the various regions of the globe. This is Evolution on a plane; and the implication is that since the rise of the great families in the Mesozoic ages little else has been effected.

The Differentiation hypothesis.—Although this hypothesis has rarely been formulated, there are various ways of stating it. It appears in a variety of guises in many a monograph of the families. The writer's mode of presenting it is to associate it with another theory relating to the differentiation of conditions, the modification of form being regarded as the response to the progressive differentiation of conditions. But it would be possible to deal independently with the differentiation through the ages of the family into tribes, of the tribe into genera, and of the genus into species. Yet the two are commonly implied, and it is hard to dissociate the idea of differentiation of type from that of diversification of condition. There may, however, be different ways of stating the relation. The following is the writer's method of doing so.

He has come to close quarters with the central problem in successive stages. In the first stage the world, as far as plants are concerned, was mainly a differentiating world in which wide-ranging generalized types had

differentiated in response to the progressive diversification of conditions originally uniform, a world in which the family differentiated into tribes, the tribes into genera, and the genera into species. But on perceiving that such a theory could only explain distribution where a continuous land-mass, not affected by unstable climatic conditions, was concerned, he came to recognize that the operations of the differentiating agencies had been largely controlled and directed by the divergence of the two great land-masses from the north, a control in its turn influenced by the secular fluctuations of climate and by the barriers that lay across the lines of migration. It may be stated that the progressive differentiation of floras in response to diversification of conditions has long been recognized. The era of world-wide floras, as Mr. C. Reid well puts it ('Encyclopædia Britannica,' edit. 10, vol. xxxi. p. 432), began to pass away after the Cretaceous age, and from that period onward plants have responded more and more to the differentiation of conditions and have arranged themselves more and more according to geographical boundaries and climatic zones. The general trend of events in later ages is sufficiently indicated by the frequent application to these early types by various writers of such epithets as "comprehensive," "generalized," "mixed," "synthetic," etc.

The views long advocated by Thiselton-Dyer brought about the first modification in the original interpretation of the theory, and the writer came in this way to lay stress on the point that the mingling of the floras of the eastern and western worlds might be regarded as the result of the successive migrations to and from the north polar region under the stress of climatic changes. The third stage was reached when he realized as a result of the statistical treatment of the subject, which is dealt with in later pages, that there was much in the distribution of the larger groups which the mixing of the eastern and western floras in the north polar regions would not explain. Though true of the smaller groups, as with species, the principle that the community between the Old and the New World is an affair of the north did not materialise with respect to families. On the contrary, it appeared, with regard to families of the first rank and the groups behind them, that the main features of distribution would have been much the same as they now are if the land of the globe had been gathered into a single mass. Thus the author came to distinguish between the larger and smaller groups in the response made to the great bi-cleavage of the land-surface of the globe, and to restrict the influences of the existing relations of land and sea to the smaller groups, as in the case of genera and species. This led him to perceive that if the differentiation hypothesis was valid the families and the larger groups behind them had not only ignored the bi-cleavage of the land-mass of the globe, but had been developed under conditions very different from those in which their genera and species had been produced.

The independent behaviour of the great families with respect to existing

geographical conditions opened to him a prospect of removing a serious difficulty that might have been fatal to the general theory; and that was the difficulty of conceiving the early stages in the differentiation of a type in response to the first stages of the diversification of uniform conditions. Since characters become more constant and adaptivity to present conditions becomes less marked as one proceeds up the scale from the species to the family, it was obvious that if the hypothesis was to stand a different order of things had to be postulated for the development of the larger groups, an order of things in which instability of characters was associated with uniformity of conditions. The responses of our great family types to the changes in environment are negligible. Yet the distant age of the Cretaceous that witnessed the deployment of the Angiosperms, much as we know them now, must have been preceded by an era of great instability of floral characters—characters on which the taxonomist has based his families and his groups of families, and characters that have been more or less fixed during the ages that have since elapsed.

Obviously one was here face to face with a different order of things, but some time elapsed before further progress could be made in the elaboration of the theory. Having abandoned the position that uniformity of conditions and immutability of type went together, a position that was the logical sequence of the differentiation hypothesis as at first conceived, one had either to adopt the opposite view or throw over the theory. It was not a dilemma peculiar to the differentiation theory, since the mutationist and the Darwinian evolutionist experience a similar difficulty when they deal with the genesis of the larger groups, the development of the family requiring the instability of characters which are mainly constant under present conditions. The way out of the difficulty was suggested on reading the account by Dr. Willis of the extreme uniformity of conditions in which the Podostemaceæ and Tristichaceæ live in mountain-torrents and rushing streams around the tropics, a description of a state of things approaching the primeval state as far as uniformity is concerned. He describes the great morphological changes of the floral and vegetative organs under such conditions, modifications characterized as without any adaptive significance and as the result of free mutation in every direction (Proc. Roy. Soc. vol. lxxxvii. pp. 546, 548; 1914). He speaks of "the most astonishing variety of morphological structure" under conditions of life "absolutely uniform" (*Ibid.* p. 533) On the results of the investigation of these families for many years he builds a powerful argument for the Mutation theory, and one can scarcely doubt that in time he will adopt a standpoint not essentially different from that of the Differentiation hypothesis. But what one is concerned with here is the association of extreme uniformity of conditions with extreme instability of type. It is a picture of the abnormal side of plant-life.

In explanation of the remarkable mutations of the floral organs displayed

by the Podostemaceæ, Dr. Willis connects the dorsiventrality of these organs with that of the vegetative organs, thus introducing a factor apparently subversive of all taxonomic principles. There is in his warning of the insecurity of the taxonomist's position an echo of Huxley's defiant note respecting the revolutionizing effect of the evolutionary doctrine on the principles of taxonomy and distribution. Dr. Willis wields the Podostemaceæ, as Huxley wielded the Gentians, in his attack on prevailing principles. In the case of Huxley it was concerned with the differentiation of a wide-ranging primitive family type, and one can scarcely doubt that he struck a true note in his declaration. But it applied only to the second era, the era of differentiation, the age of influences still in operation, the age of normality, if we may so term it; and it ought to have a profound effect on the methods of the taxonomist and on the principles of distribution. In the case of Dr. Willis it is concerned with the abnormal side of plant-life and does not really affect the validity of prevailing taxonomic principles. The difference is very significant, since, in view of the position taken at the commencement of this paper, we can in our day only look in that direction for a clue to the influence at work during the first era in the history of the Angiosperms, the age that witnessed the rise of the great families, the age of abnormalities, as it may be called. It is in this first era that the Mutation theory will find its appropriate field of investigation, and it is here that the principles disclosed by Dr. Willis in his prolonged investigations on the Podostemaceæ wil apply.

Before proceeding to deal in the two following paragraphs with my interpretation of the lessons to be learned from the behaviour of the Podostemaceæ and with their application to the first era, I may say that Dr. Willis left room for an interpretation of the same kind, but was prevented, as he tells me, from entering a domain of pure surmise.

Postulating for terrestrial plants an era when uniformity in environment was the rule—an era, one might imagine, of great atmospheric humidity, when persistent cloud-coverings blanketed the globe and when the same equable temperature everywhere prevailed,—the writer pictured a plant-organism under such conditions as behaving very much like a ship in a calm, drifting in a morphological sense in all directions and displaying unchecked and irresponsive variations of the floral organs of a kind very disquieting to the taxonomist and all non-adaptive in their nature. He came to see that such modifications would become more and more fixed as the differentiation of conditions proceeded, the degree of mutability varying inversely with the diversification of environment.

Stated in the language of the mutationist, this would imply that the mutations of the floral organs of our own day represent all that remains of the capacity for great morphological changes in the early ages of the history of the Angiosperms. A mutation as at present recognized is non-adaptive.

Yet it may be adaptive in another sense—namely, in its response to the remnant of the conditions of an age long passed away. One might regard it as the last kick of the organism in response to what remains of the primeval uniformity of conditions, its last effort to break through the ever-contracting ring of the differentiating agencies. The farther we go back the greater is the capacity for mutations and the greater will be the mutations; and it is argued that they ought to be more frequent and more extensive in plant-groups of large than of small range. A large mutation would usually be impossible nowadays except under conditions approaching those of the early ages in their uniformity. One would look for some approach to those times in the dense forests of tropical lowlands and in the forests of the cloud-belt or rain-zone on tropical mountains.

The ascription of periodicity to mutability by De Vries is well known, and appeals to this principle in elucidation of the rapid rise of the Angiosperms in the Cretaceous period have been made; but the question, why basic characters so mutable then are stable now, always remains. The position is well put by Harshberger in his great work, 'The Phytogeographic Survey of North America,' p. 173, 1911. "If this periodicity of mutation (so he writes) is recognized as an evolutionary principle, we have a reasonable explanation for the sudden appearance of so many new forms during the Cretaceous period, for during this stage of the development of the vegetable kingdom, through causes yet unknown, the progenitors of the existing phanerogams were in a high state of mutability."

A few remarks may here be made on the relation of the views of distribution here advocated to the Age and Area theory of Dr. Willis. If one for the moment ignores his adoption of the prevailing practice of building up a family from the species, there is but little that is essentially inconsistent with the differentiation hypothesis. Had he formally associated with his Age and Area principle the twin principle of Rank and Range, and all that it implies, he could not have avoided coming into line in this matter. Since he extends his views to the larger groups, his Age and Area theory is of general application, and his conception of the distribution of families, apart from his standpoint of their genesis, might very well have been acquired in a line of argument favouring the views supported in this paper. His discussions of the Dilleniaceæ, Menispermaceæ, and Podostemaceæ are cases in point. (See Ann. Roy. Bot. Gard. Peradeniya, 1902, 1907; Phil. Trans. Roy. Soc. Lond. 1915; Proc. Roy. Soc. 1914; Ann. Bot. 1915, etc.) Thus he connects the origin of these three pantropical families with the most primitive and most widely distributed genera—genera that almost possess the range of the families. This is differentiation pure and simple. Then again, though he departs from the principle of differentiation when he endeavours to find the original centre of dispersion or home of the Dilleniaceæ, he comes very near it in the case of the Menispermaceæ in his

inference that the primitive genera "must have commenced when there was still a possibility of reaching both the great land masses" (Phil. Trans. *ibid.* p. 338). This recalls Bentham's opinion respecting the Compositæ, that the two hemispheres, the east and the west, must have possessed the family at its earliest recognizable stage.

So, again, when he observes in connection with the Podostemaceæ and Tristichaceæ that "the only widespread genera are the non-specialised ones, whilst the more specialised the genus, on the whole, the less is its area of distribution" (Proc. Roy. Soc. 1914, p. 545), and when he remarks that "the larger the group and the fewer the characters on which it is based, the greater the likelihood of its being polyphyletic"—that is to say, of arising independently in localities remote from each other (Ann. Roy. Bot. Gard. Perad. p. 447, 1902),—he is expressing the differentiation standpoint. But the writer cannot conceive how the principle, often implied in the foregoing remarks, that the simpler the form the wider its range, could apply to groups that have been built up, as Dr. Willis infers, by the species taking the generic step, the genus the tribal step, and the tribe the family step (*ibid.*).

But, apart from this, there is a great deal that links together the two views of distribution; yet one may add that whatever view we take of distribution, whether that of the Darwinian evolutionist, or that of the Mutationist, or that of the advocate of pure differentiation, we all get into the same dilemma when we handle the larger groups. If we require for their development the mutability or instability of the characters on which the taxonomist bases his larger groups, characters that in our own age are relatively immutable, we cannot look to existing prevailing conditions for guidance in the matter. However, Dr. Willis in his account of the astounding modifications experienced by the Podostemaceæ, under conditions described by him as "unique" among plants, offers, as the writer has already explained, a way out of the difficulty.

The statistical treatment of Distribution.—If the Differentiation hypothesis is valid, we may now ask what we should be justified in expecting from a statistical treatment of the main features of plant-distribution. If we listen to the story of the early stages in the distribution of the Compositæ and Gentianaceæ, as interpreted by Bentham and Huxley, we should expect that the larger plant-groups would to a great extent ignore the cleavage of the land of the globe into two large masses diverging from the north, and that the response made to the existing arrangement of land and sea would increase as we go down the differentiating scale, being least for the family and greatest for the species. On the other hand, we should expect a marked response of the larger plant-groups to the climatic differentiation of the latitudinal zones.

If in our investigations with the family as our starting-point we disclose a method and a system that could not be brought about by a procedure so haphazard as that involved in commencing the genetic sequence with the

species and ending with the family, then we shall make an important step towards the proper appreciation of the main problems concerned in distribution. That two such opposite methods should seem possible, as beginning in one case with the species and the other with the family, and that we should be indifferent to the result, whether it be chaos or order, are indications of failure to appreciate what really matters in plant-distribution.

It is by no means urgent to go back to the beginning of things, to account for the origin of families or even of species, to seek for centres of dispersion or the homes of plant-groups, to upset the world's geography, or to account for progressive evolution. What is urgent is to be able to state the main problem, and that cannot be done without some agreement about essentials. One cannot help thinking that if a hundred students of distribution were asked to do this, they would view the subject from such a variety of standpoints that the task of finding a common basis of agreement would be exceedingly difficult. The claim of the family for priority of treatment, which is supported in this paper, is founded on what Bentham terms in the case of the Compositæ the permanence of its characters. The very persistence of the family lies in the fact that these characters make little or no response to the extreme variations of existing conditions; and it is with the object of emphasizing its suitability for serving as a common ground of agreement that these pages have been written.

The response of the families to the bi-cleavage of the land-mass of the globe.—It is a remarkable fact that whilst the families of the Angiosperms respond in a marked degree to the differentiation of the climatic zones, they largely ignore the cleavage of the land into two great masses diverging from the north. Of the 272 families recognized in Engler's system 192, or 70·5 per cent., occur in both the eastern and western hemispheres (Tables I., II., III.). It would almost appear, as far as their occurrence in both hemispheres is concerned, that the general distribution of the families over the globe would not have been very different if all the land had been one continuous little-divided mass.

It may, however, be objected that this community of families between the Old and the New World may be mainly restricted to those most at home in the colder latitudes of the north where the American and Eurasian land-masses approach each other. If this were so, there would be but little force in the above contention that the family largely ignores the bi-cleavage of the land. But a glance at the columns of Table III. will convince one that this behaviour of the family is just as characteristic of the warm equatorial regions as it is of the colder northern regions. There are 120 families restricted to tropical and sub-tropical latitudes. Of these 73, or 61 per cent., are found in both the eastern and western worlds. There are 52 families that are only at home in extra-tropical regions. After removing those confined to the southern hemisphere, there remain 36, of which 23, or 64 per

cent., occur in both the Old and New Worlds. We obtain similar indications by also introducing the element of those families that are mainly, though not exclusively, either tropical or temperate. Thus, by extending the method employed in Tables IV. and V., we arrive at the conclusion that whilst 69 per cent. of the families that are mainly or exclusively tropical (158 in all) occur in both the Old and New Worlds, the proportion for families exclusively or mainly extra-tropical in the northern hemisphere (62 in all) is 77 per cent. (consult note at end of the paper). Under the circumstances the difference is small, and there is little to support the objection that the families common to the east and the west gather in high northern latitudes. But it would have been enough to point out that there is little room for such an objection in view of the fact that the proportion of tropical families that are common to the eastern and western worlds (69 per cent.) is very close to the proportion obtained for the families of the Angiosperms in the mass (70 per cent.).

The question whether the connection by families between the Old and the New World is chiefly a problem of the cold regions of the north, where the great American and Eurasian land-masses converge, is sufficiently answered by the behaviour of the seven terrestrial sub-families of the Araceæ. All of them occur in both the eastern and the western worlds, yet four of them are exclusively tropical, two are distributed in both the tropical and the temperate zones, and only one (Calloideæ) is restricted to cold northern latitudes. This last seems to be the only one of the seven sub-families that holds species common to the east and the west.

We have now raised a very interesting point. Although the families common to the two worlds do not gather in the north, the species behave in a very different fashion. It is there that the species common to the east and the west mostly congregate. Thus Harshberger states that of the 364 species of phanerogamic plants found in arctic western America, 320, or about 87 per cent., occur in temperate and arctic Asia; while of the 379 species in arctic east America, 239, or 63 per cent., are also found in the arctic regions of Europe ('Phytogeographic Survey of North America,' pp. 311, 312; 1911). The community of species rapidly diminishes as we leave the north behind until we reach the tropics, where with the exception of a few littoral, aquatic, and marsh plants, it disappears altogether, or is only represented by a few plants, some of them not free from suspicion as regards man's agency.

When we have two complemental families like the Myrsinaceæ and the Primulaceæ, the first tropical and the second temperate, it is the temperate family that alone displays a community of species between the two hemispheres.

The manner in which the proportion of species held in common dwindles as we go south is well illustrated by *Carex*. In the author's recent book on

the West Indies he has shown that the proportion of species which North America holds in common with Eurasia is 93 per cent. in the arctic regions, 40 per cent. in the sub-arctic regions, 24 per cent. in temperate latitudes, and 11 per cent. in the southern portion of the continent. If we take the total *Carex* floras of the eastern and western worlds in the northern hemisphere, we find that 80 per cent. of the species held in common are arctic, 29 per cent. sub-arctic, and 11 per cent. temperate. There are about 150 species common to North America and Eurasia, and of these two-thirds are arctic and sub-arctic species.

I am not able here to deal fully with the distribution of genera from this standpoint, but it cannot be doubted that the behaviour of genera common to both the eastern and western worlds will be intermediate between that of the species and families similarly distributed. This is established below in an analysis I have made of the list of the chief genera of the Angiosperms (about 3150) that is given by Dr. Willis in his 'Flowering Plants and Ferns,' 1908.

It has already been shown that whilst 69 per cent. of the families that are exclusively or mainly tropical (the subtropical regions being here included) occur in both the Old and the New Worlds, the proportion for families that are exclusively or mainly extratropical in the northern hemisphere is 77 per cent. On the other hand, with the genera that are mainly or exclusively tropical the proportion found in both worlds is only 23 per cent. (408 out of 1781), whilst with those mainly or exclusively restricted to regions beyond the tropics in the northern hemisphere the proportion is 42 per cent. (437 out of 1045). The genera, therefore, are in their behaviour intermediate between the families and the species. Whilst with the species nearly all (80–90 per cent.) of those common to the eastern and western worlds gather in the high latitudes of the north, with the families there is but a small tendency in this direction, and reasons have been before given for the belief that this tendency is even smaller than is above indicated. With the genera the proportions common to both worlds would be, as before noted, 23 per cent. for the tropics and 42 per cent. for the cooler latitudes of the north, and my figures suggest that north of the warm temperate region it would be at least 50 per cent.

Rightly interpreted, there should be a great significance in the principle that the tendency to congregate in the north on the part of plants represented in the eastern and western hemispheres is greatest and well marked with the species and least or non-existent with the family. The connections in the north belong to the later stages of the differentiating process, whilst the disconnections of the south date back to remote antiquity. One would have imagined that during the long ages that have passed the ocean-parted eastern and western worlds would have possessed scarcely a family in common, except in the north. Yet, as already shown, 69 or 70 per cent.

of the exclusively and mainly tropical families are common property of the Old and the New Worlds. All the influences that have been in operation in a differentiating world during an incalculable period of time have in a general sense not materially defaced the primitive family type, and the wonder is not that the differentiating agencies have done so much but that in this respect they have effected so little.

Yet, as we have seen, about 30 per cent. of the families do respond to the bi-cleavage of the land represented in the American and Eurasian hemispheres. (This applies, of course, only to the families in the mass, the proportion, as shown in a note to Table III., being much smaller, if we regard only the principal families.) But the differentiation, or the break-up, of the original family-type has proceeded far more rapidly in the New than in the Old World. In its development of new families the western hemisphere displays for its size nearly twice the capacity that is exhibited by the eastern hemisphere. Of the eighty residual families that are restricted either to one hemisphere or to the other (see Tables I., II.), one would have expected the Old World to possess by far the greater number, since the land-areas of the two hemispheres stand to each other in proportions exceeding two to one (O.W. 35; N.W. 15; based on data given in Whitaker's Almanack, 1917, p. 101, the polar regions being excluded, Australia being included in the Old World). But, to one's surprise, the difference in the number of families peculiar to each is relatively small, 45 being appropriated by the eastern and 35 by the western hemisphere. There will subsequently be occasion to mention this point again in association with another remarkable contrast presented by the New World with regard to the Old World.

[One may take this opportunity to observe that the excess in families in proportion to its area held exclusively by the New World is apparently not exhibited to the same degree by the genera. Of the 3150 genera of the Angiosperms named by Willis in his 'Flowering Plants and Ferns' (1908), the Old World appropriates 47 per cent. and the New World 25 per cent., about 28 per cent. being held in common. Of 529 genera belonging to 42 families dealt with in the 'Pflanzenreich' series, 51 per cent. are peculiar to the Old World, 32 per cent. to the New World, and 17 per cent. are common to both. The difference between the two worlds with regard to their peculiar families and genera may be thus expressed. With the families the difference would be as 9 (O.W.) to 7 (N.W), but with the genera as 9 (O.W.) to 5 (N.W.).]

We have already observed that as many as 70 per cent. of the families do not respond to the great bi-cleavage of the land-surface of the globe, distributed as they are in both the eastern and western hemispheres. The response becomes greater and greater as we proceed down the scale from the family to the species. Thus the proportions common to the two

hemispheres are about 56 per cent. for the tribes, less than 20 per cent. for the genera, and about 1 per cent. for the species. As indicated in the table of results (Table I.), this subject has only been sampled for the tribes, genera, and species; but reference should there be made to the accompanying explanatory remarks. Yet the consistency in the results leaves no doubt that the general behaviour of the tribe, the genus, and the species is correctly illustrated in the above percentages. Here we perceive that the connection between the Old and the New Worlds is greatest with the family, less with the tribe, smaller still with the genus, and least with the species. Such a result is in perfect accord with what we should expect from the successive differentiations of a world-ranging family-type into tribe, genus, and species, the range contracting as one goes down the scale. The effect of the opposite method of regarding the species as diverging into the genus, the genus into the tribe, and the tribe into the family would be chaos.

But although 70 per cent. of the families occur in both worlds they represent in very different degrees the community in families between the east and the west. For instance, the original distribution of the generalized family-type in both worlds would be best exemplified now by a family of which all the tribes belong to both hemispheres. At the other extreme the connection implied by the community in families between the Old and the New World would be near its breaking-point in a family where no tribes were the common property of both hemispheres, and where most of the tribes were gathered together in one of them. The possibility thus presents itself of constructing a scale representing the various stages of detachment from a both-world distribution. Taking an imaginary family holding thirteen tribes the writer has framed such a scale, the first grade claiming the families where all, or nearly all, the tribes are common to both worlds, the complete detachment being illustrated in the eighth or last grade, where all the tribes are restricted to one and the same hemisphere. Such a grading of families would raise many difficulties, some of which ought not to prove insurmountable for the differentiation hypothesis. It is not possible, however, to do much more than draw attention to this method here. It will be sufficient to mention that the Compositæ, the Araceæ, and the Betulaceæ representing, respectively, the cosmopolitan, the tropical, and the temperate families, would find their place in the first grade. But the anomalies of this sort that are displayed in framing such a scale are in themselves instructive; and it is to be doubted whether a much more effective plan could be devised to illustrate the unequal value of families and to emphasize the necessity of grouping all families under a few great alliances. For instance, the Scitamineæ are represented in this scale by four families, the Marantaceæ, the Zingiberaceæ, the Musaceæ, and the Cannaceæ, which are scattered up and down its grades. From the stand-

point of the differentiation theory its place would obviously be in the first grade, together with the Compositæ and the Araceæ.

Having shown that the response to the cleavage of the land into two main masses, diverging from the north polar regions, increases with the Angiosperms as we go down the differentiating scale from the family to the species, being small with the family and very pronounced with the species, we will for a moment direct our attention to the behaviour of the great groups, or the cohorts, that lie immediately behind the families. As might have been expected, the response is even less than with the families. With the families about 70 per cent. ignore the cleavage. With the cohorts, on the other hand, 91 per cent., or 41 out of 45, are represented in both the eastern and western worlds (Table I.). It is noteworthy that the four cohorts that are exceptions to the rule hold in each case only a single family, the Cyclanthaceæ, the Leitneriaceæ, the Casuarinaceæ, and the Balanopsidaceæ, all of them tropical, the first two belonging to the New World and the last two to the Old World. They are all small anomalous families which have puzzled the systematist in his endeavours to place them. Together they represent the flotsam and jetsam of an ever-differentiating plant-world.

The response of the families to the differentiation of the climatic zones.—Although the families of the Angiosperms make a relatively small response to the bi-cleavage of the land-surface of the globe, their behaviour under the stress of climatic differentiation has been very different. From the tables (IV. and V.) it will be seen that nearly 60 per cent. of them are exclusively or mainly tropical, about 30 per cent. exclusively or mainly temperate, and about 10 per cent. fairly divided between the tropical and the temperate zones, all the regions outside the sub-tropics being regarded as temperate. Since the differentiation theory postulates an early age in the history of the Angiosperms when primitive generalized types ranged the globe and uniform climatic conditions prevailed, the later ages being occupied with the differentiation of types in response to the diversification of climate, it follows that the results for families above given represent a particular stage in the detachment or individualization of temperate floras.

When we look to the future and ask ourselves what will be the ultimate result of this gradual detachment of the temperate from the tropical floras, we shall be obliged to confess that there is little more to expect now. We might have looked far ahead to an age when the tropical and temperate floras would be sharply differentiated, an age when the world would be held by complemental families representing the independent expression of tropical and temperate conditions on the same type. But the influence of climatic differentiation is largely played out. Nature in the development of new forms seems to have mainly exhausted her efforts during the Upper Cretaceous period. That which has happened since has been principally the effect of the differentiation of ancient types in response to the progressive

diversification of conditions, and all we have to look for is the assertion of man's predominance in his replacement of natural floras by his cultivated plants and his weeds. The time for revolutions in the plant-world was spent geological ages ago; and Nature in her present operations can offer us but little aid in unravelling the revolutionary past.

The subject of the detachment of the temperate from the tropical floras during the ages through which the differentiating influences have reigned supreme, brings up the question of the complemental families, those which, although now ranked as distinct families in the tropical and temperate zones, are so closely linked together that they may be regarded as the result of the differentiation of the same world-ranging family-type. Thus we may view the Primulaceæ in the temperate regions and the Myrsinaceæ in the tropics as complemental to each other and as representing the first step in the differentiation of a common parent type. In the same way and with the same implications we may link the Umbelliferæ (temperate) with the Araliaceæ (tropical), and the Chenopodiaceæ (temperate) with the Amarantaceæ (tropical).

But the effect of the secular differentiation of climatic conditions and of the individualization of the temperate zones has not always been the development of a world-ranging type into separate tropical and temperate families. Some, like the Compositæ, have, as far as the retention of family characters is concerned, defied the differentiating agencies. In yielding to the exigencies of the differentiation of climates, though still holding the world, they have retained in this case the essential characters of the family, on the absolute permanence of which, in the case of the Compositæ, Bentham lays stress. Others like the Scitamineæ are still confined to their original home in the equatorial regions of the globe, having failed to adapt themselves to the newly differentiated temperate zones. They have given rise to separate sub-families, often ranked as families, in the different warm regions of the globe, but in no sense as the result of the secular diversification of climate.

We have remarked that the work of the differentiation of floras is largely spent, as far as climatic influences are concerned. Yet, great as this work has been, we are, as the writer thinks, not justified in regarding it from any other standpoint than that of adaptivity. It is not the work that was carried on in those remote Mesozoic ages when the larger plant-groups, now represented by the alliances of families and by the cosmopolitan and pan-tropical families, were first developed. The characters that distinguished them then distinguish them now, and as far as their essential characters are concerned they have made but little response to the great climatic differentiation of the ages. The rise of the Xerophytes presents one of the most important and far-reaching results in the story of distribution and differentiation. Yet they are of the later and not of the earlier age; and it is

questionable whether any truly natural family comparable with the great families has been developed through the changes inducing the xerophytic organization. They might disguise them, as in the case of the Cactaceæ and of some of the Euphorbiaceæ ; but the essential floral characters were produced in pre-xerophytic times. A family in its truest sense is born and not made.

It may here be added that the process of detachment of temperate families from the tropics has not been uniform in the two hemispheres, the east and the west, the tendency to the differentiation or detachment of temperate families in the Old World being far more marked than in the case of the New World. Thus, with the exclusively Old World families 44 per cent., or 20 out of 45, are restricted to the tropics, using that term as including the sub-tropics ; whilst with the exclusively New World families the proportion is as high as 77 per cent., or 27 out of 35 (Table III.). Thus it also appears that the tropics of the American continents actually possess a greater number of peculiar families than those of the Old World. This feature of American plant-distribution is to be associated with another feature, already alluded to and illustrated in the same table, the New World in its entirety owning nearly as many peculiar or endemic families as the Old World, 35 against 45, though barely half its size. In the New World, therefore, there has been not merely a greater development of families, but a greater segregation of such families within the tropics. In other words, although the process of detachment of temperate families from the tropics has been far less effective in the New World than in the Old World, the differentiation of new families in the American tropics has been far greater. This is one of the lessons supplied by the western hemisphere when treated statistically from the standpoint of the differentiation hypothesis. [Reference has before been made to the contrast in behaviour of the genera in one of these respects.]

Before quitting the subject of the influence of the differentiation of the climatic zones on the development of the families, a few remarks may be devoted to the numerical distribution of the families of the Angiosperms in the north and south hemispheres, which is illustrated in Tables VIII., IX., X. The matter cannot be discussed at any length here ; but it may be observed that the numerical apportionment is much as though the land-areas in the two hemispheres were approximately the same in extent. Yet within the limits of vegetation there must be at least $2\frac{1}{2}$ times as much land in the northern as there is in the southern hemisphere. The differentiation of families has thus been far more active in the south than in the north, a result that might be attributed to the much greater isolation of the southern land-masses.

The larger plant-groups behind the families.—We have already dealt with the cohorts in connection with the families, and it has been shown that as

far as the principle of differentiation is concerned they behave conformably with their position in the differentiating scale just above the families. Before one proceeds to deal statistically with the large groups of the Angiosperms that lie behind the cohorts, a word may be said regarding the needs of the differentiation hypothesis in this respect. Between the 45 cohorts and the two classes of the Monocotyledons and Dicotyledons, there is a considerable break or gap in the differentiating scale, which cannot be very satisfactorily bridged over by dividing up the Dicotyledons in a few groups as is done below. The advocate of the differentiation theory, and the writer ventures to think that his need is also that of the systematist, requires an intermediate group holding about a score or two dozen great alliances, each of them cosmopolitan or pantropical, and all families of restricted range will have to be reduced to terms of an alliance. Here geographical considerations would be foremost, and the complemental families as above described would take a prominent part in building up an alliance which would either possess the tropics or hold the world, the pantropical and cosmopolitan alliances being regarded as of equal value, notwithstanding the failure of the first-named to respond to the differentiation of the temperate zone. The object would be to restore the original world-ranging generalized types; and if the number of such great alliances should exceed the limits above named, they would serve to displace the cohorts which could then be very well dispensed with. One would commend the use of familiar designations for all the alliances, such as Compositæ, Rubiaceæ, Ericales, Leguminosæ, Scitamineæ, Aroideæ, Palmæ, etc. But in restoring the original type in the shape of an alliance we should give it the name of the tropical parent form where a cosmopolitan alliance is concerned. Any names like Geraniales and Primulales that would seem to credit the alliance with an origin in the temperate zones should give place to the name of the older tropical forms.

The Monocotyledons and Dicotyledons.—Notwithstanding the great disparity in the number of families they hold (Monocotyledons 43, Dicotyledons 229), some interesting comparisons can be made. In the first place, it will be worth while ascertaining how they stand to each other with reference to the proportion of families occurring in both hemispheres, the east and the west. They differ but little in this respect, since the proportion is 76·8 per cent. for the Monocotyledons and 69·4 per cent. for the Dicotyledons (Table II.). This approximation exists in spite of the circumstance that 30 per cent. of the Monocotyledonous families are aquatic or sub-aquatic (Table V.). Of the 272 families of the Angiosperms 26 are aquatic or sub-aquatic, and of these half (13) are Monocotyledons. It would therefore appear that as regards the occurrence of a family in both the Old and the New Worlds it behaves the same, whether monocotyledonous or dicotyledonous, or whether aquatic or terrestrial in habit. This independence of the proportion of aquatic plants is also displayed, as will subsequently be shown, by the

subdivisions of the Dicotyledons with respect to this feature in distribution. Sympetalæ and Monocotyledons are distributed in the same proportions in both worlds, as respects their families, although the first holds only 2 per cent. of aquatic families and the second as much as 30 per cent. Yet it is true that the large proportion of aquatic families exercises an influence in determining the distribution of Monocotyledons; but, as is established below, that influence is mainly concerned in curtailing their latitudinal extension and affects but slightly, as already shown, their response to the bi-cleavage of the land, as indicated by the proportion of families existing in both hemispheres.

Although the Monocotyledons and the Dicotyledons are at one in the similar responses of their families to the great cleavage of the land, they differ much in the responses made by their families to the differentiation of the latitudinal climatic zones. Whilst, as shown in Tables IV. and V., both classes hold about the same proportion of exclusively or mainly tropical families, 58 and 59 per cent. respectively, yet in the case of the Dicotyledons nearly all of the residue are either mainly or exclusively temperate, while with the Monocotyledons two-thirds of the remainder are fairly well shared between the tropical and temperate zones. It is thus evident that as regards the differentiation or separation of temperate floras from the original tropical floras, the Dicotyledons are in a much more advanced stage than the Monocotyledons. The equal sharing between the tropical and temperate zones of a family originally tropical represents the first stage in the detachment of a temperate family. The appropriation of a family by the temperate zones represents the last stage in the detachment of a family from its original abode in the tropics. This last stage has been attained by 21 per cent. of the families of the Dicotyledons and by only 7 per cent. of those of the Monocotyledons (Tables IV., V.), the last-named having lagged behind the Dicotyledons to a marked degree as regards the differentiation or detachment of temperate floras. The contrast may be stated in another way. Thus, whilst 34 per cent. of the families of the Dicotyledons are either temperate or mainly temperate, the proportion for the Monocotyledons is only 14 per cent. This may be due to the greater prevalence of aquatic families among the Monocotyledons. Here the proportion is as much as 30 per cent., that for the Dicotyledons being under 6 per cent. (Table V.). The explanation would be that aquatic conditions present a much smaller contrast between the temperate and tropical zones than is offered by those of land plants.

The conclusions to be drawn from the behaviour of the great plant-groups of the Angiosperms.—Although the present arrangement of the main land-masses and of the oceans is largely ignored by the great plant-groups, the response becomes more and more evident as we go down the differentiating scale. It goes without saying that in whatever way we split up the Dicotyledons, whether in two or three or four groups, all the primary groups of

the Angiosperms, commencing with the Monocotyledons and ending with the Sympetalæ, take no heed of the present distribution of land and water. But there is a slight response for the cohorts, 9 per cent. of them being restricted to either the New or the Old World. Of the families 30 per cent., of the tribes about 44 per cent., of the genera at least 80 per cent., and of the species about 99 per cent. respond to the cleavage of the land into two main masses diverging from the north polar regions (Table I.).

This contrast in the behaviour of the larger and lesser plant-groups implies a very great contrast in geographical and climatic conditions. There would seem to have been a pre-differentiation era that corresponded with geographical and climatic conditions very different from those that now prevail. At that time generalized types ranged the globe and the conditions were far more uniform than at present. It was an age, we imagine, when floral mutations were relatively unchecked. After that era the age of differentiating conditions began, the effect of the progressive differentiation of conditions being to restrict more and more the play of mutation in the case of the floral organs, so that in our age the capacity is rarely exercised. In the pre-differentiation era the generalized type had the whole earth for its range and uniformity of conditions for its "mise-en-scène," a setting that was destroyed when climate began to individualize. During such an era reigned other things, other ways, and other conditions.

If we were to draw a line dividing this distant era from the succeeding ages of differentiation, we should draw it just below the great family groups as illustrated by the Compositæ and the Araceæ; and if we were to contrast the geographical conditions, we should point to the fact that whilst the family and the groups behind it or above it mainly or entirely ignore the existing arrangement of land and sea, the genus and the species are in a sense the offspring of it. Distribution in the distant past was chiefly a story of generalized family types. In the later ages it has been principally a story of the genus and the species and of adaptive response to the progressive differentiation of conditions. The failure of the larger plant-groups to respond to the great bi-cleavage of the land-mass and their subsequent ready response to climatic differentiation mark out the two great eras—the pre-differentiation age and the age of differentiation that followed.

What is earliest in distribution belongs to the family and the large groups behind it. What is recent belongs to the genus and the species. To employ the terms "genus" and "species" when speaking of an age different in almost every respect from the present one is to muddy the waters, or, rather, to confuse the issues. Such a habit assumes that the present is like the past, that we can picture what has been from what is. Yet to think only in terms of genera and species is to ignore the better half of the story of the development of the plant-world. The age that witnessed the rise of

the great families and the age that witnessed their subsequent differentiation are things apart, and cannot be dealt with by the same method.

If one were asked how such a view of distribution could be reconciled with that of the animal world, one might reply that since plants and animals have been developed on quite different plans, the plant requires an application of the Darwinian theory of evolution, in which this distinction is recognized. In the one case development has centred around provisions for securing the continuance of the like. In the other it has been concentrated on the production of a higher order of beings culminating in Man. The first secured, the second became possible.

Note on the sub-divisions of the Dicotyledons.

In order to make a further statistical comparison of the Dicotyledons with the Monocotyledons, the number of families in the first being according to Engler's system more than five times those of the second, the Archichlamydeæ have been broken up into four groups, making with the Sympetalæ five groups for the class. For this purpose the system of Engler was preferred, since a scale of development is implied in the arrangement adopted ; whilst with that of Bentham and Hooker the placing of more than a fifth of the families there recognized in the Incompletæ makes a linear classification impracticable. Yet it was the Incompletæ that led the writer to pay attention to this matter, with the result that the group viewed from this standpoint appears to be very far from an anomalous group. On the contrary, when treated statistically it proves to be the most typical, as far as percentages are concerned, of all the groups of the Dicotyledons.

Assuming that the series—Monocotyledons, Archichlamydeæ, Sympetalæ—represents a scale of plant-development and that the same is indicated in the arrangement of the groups of families of the Archichlamydeæ, the writer broke up the last-named into four groups and obtained the following succession :—

Monocotyledons, holding 43 families.

Dicotyledons	Archichlamydeæ	Group A.	Cohorts 1–14	with 37 families.
		„ B.	„ 15–18	„ 41 „
		„ C.	„ 19–21	„ 42 „
		„ D.	„ 22–26	„ 58 „
	Sympetalæ, holding 51 families.			

Group A includes 25 of the 37 families in Monochlamydeæ or Incompletæ of Bentham and Hooker. Group B comprises the cohorts Ranales, Rhœadales, Sarraceniales, and Rosales ; Group C, the cohorts Geraniales, Sapindales, and Rhamnales ; and Group D, the cohorts Malvales, Parietales, Opuntiales, Myrtifloræ, and Umbellifloræ.

Together here we have six groups which we will term the Primaries, and

in order to give point to their statistical treatment we will assume the truth of the implication of Engler's system that they represent a genetic sequence commencing with the Monocotyledons and terminating with the Sympetalæ. It would have been possible to discuss this matter at considerable length; but as the treatment is purely tentative a few general remarks will be here sufficient, and the columns of the tables (II., IV.–VIII.) will be allowed largely to tell their own story.

It will be at once noticed that whilst the six primary groups of the Angiosperms behave with comparative uniformity in matters concerned with the bi-cleavage of the land-mass, as reflected in their distribution in the Old and New Worlds, they often present marked contrast in their responses to the differentiation of the climatic zones. Thus, to take their behaviour in the first case, the proportions of families occurring in both the east and west hemispheres vary only between 62 and 77 per cent. (Table II.); and if we limit the comparison to the families of world-wide distribution, termed cosmopolitan in the table, the percentages range only between 21 and 33 (Table VII.). We find a like agreement in the proportion of families confined either to the Old or to the New World. Thus, the percentage of families restricted to the eastern hemisphere varies only between 12 and 24 and of those peculiar to the western world only between 11 and 14 (Table II.). This conformity is remarkable when we reflect that in small groups of this kind we can only appreciate general approximations or marked deviations. The similarity in behaviour on the part of the six primary groups respecting the distribution of their families in the eastern and western hemispheres is quite independent of the proportion of aquatic and sub-aquatic families in each group, which is as high as 30 per cent. for the Monocotyledons and as low as 2 per cent. for the Sympetalæ (Table V.).

Yet this similarity in behaviour disappears when we regard the response made by these six primary groups to the differentiation of the climatic zones. As indicated in Table V., they display great variety in the appropriation of their families by the tropical and temperate zones. Thus Groups C and D of the Archichlamydeæ are the most tropical; and Group B and the Sympetalæ are the least tropical; whilst the Monocotyledons and Group A stand between. On the other hand, the Monocotyledons are by far the least temperate of all the groups, which is to be associated with the fact that a much larger proportion of the families are in a transition state—that is, are equally divided between the zones—than is the case with the other groups. Then again Group A is in these respects the most average of the six primary groups, approaching nearest in its behaviour to that of the Dicotyledons in the mass and nearer still to that of the Angiosperms. It comes closest to the Incompletæ of Bentham and Hooker, a result to be expected since the two equal-sized groups hold about two-thirds of their families in common; whilst the group of the Incompletæ in its response to

the differentiation of the climatic zone is the most typical of all, making a near approach to the Dicotyledons in their entirety and the nearest of all to the Angiosperms in the mass (Table V.).

Comparison may now be made between the Monocotyledons and the Sympetalæ as representing the extremes of the series constituted by the six primary groups. It has been shown in an earlier page that with regard to the detachment or differentiation of temperate floras from the original tropical flora the Dicotyledons are far in advance of the Monocotyledons. But, as indicated in the columns of Table V., the five groups of the Dicotyledons exhibit considerable divergencies in their behaviour in this respect ; and it is not possible to construct a series with the Monocotyledons and the Sympetalæ at the extremes. Yet in view of the position of these two groups at the extremes of the series accepted by some systematists, a brief comparison may be profitable. The escape of the Sympetalæ from the tropics, as contrasted with the lagging behind of the Monocotyledons, is illustrated in different fashions in the columns of Tables IV., V., and VII. Nearly all the tropical families of the group last named, that is 23 out of 25, are exclusively tropical. With the Sympetalæ only 14 out of the 25 tropical families are exclusively tropical. Then, again, whilst 12 out of the 43 families of the Monocotyledons are fairly well shared between the tropical and temperate zones, with the Sympetalæ the number of families shared is 4 out of 51, or only about 8 per cent. The bulk of the non-tropical families of the Monocotyledons are in fact in the transition state. With the Sympetalæ the non-tropical families have in most cases reached a further stage and are more or less completely detached from the tropics. Whilst with the Monocotyledons the families exclusively tropical amount to 53 per cent. and those exclusively or mainly temperate to only 14 per cent., with the Sympetalæ only about 27 per cent. of the families are confined to tropical regions and as many as 43 or 44 per cent. are exclusively or mainly temperate. A possible explanation of the contrast in behaviour between these two groups is supplied in the great predominance of families of aquatic habit in the Monocotyledons (see Table V.) ; but this is a matter discussed in the following note.

Note on the influence of aquatic and sub-aquatic families on the distribution of the Angiosperms.

The apportionment of the families of aquatic habit between the larger groups of the Angiosperms and their distribution over the eastern and western hemispheres are illustrated in Tables V. and VI. Of the 26 aquatic families recognized by the writer, 13, or half, are appropriated by the Monocotyledons, 12 belong to the Archichlamydeæ, and only 1 to the Sympetalæ, namely the Lentibulariaceæ. It has been shown that it makes

but little difference in the distribution of the larger family-groups in the eastern and western hemispheres whether they hold many or few aquatic families Thus the Monocotyledons holding 30 per cent. of these families and the Sympetalæ holding only 2 per cent. are distributed in the same proportion over the Old and New Worlds, in each case about 77 per cent. of their families being common to the two hemispheres (Table II.). The aquatic families are therefore quite neutral in their influence on the general response of the Angiosperms to the great bi-cleavage of the land-mass of the globe.

On the other hand, they sometimes seem to have a marked influence on the response made by families to the differentiation of the climatic zones. Thus, as shown in the previous note, the Monocotyledons lag behind the Sympetalæ to a marked degree in the detachment of temperate families from the tropics ; and the implication is that since the former hold as many as 30 per cent. of aquatic families, and the latter as few as 2 per cent., the influence of the aquatic habit in checking the process of differentiation is displayed in the diminution of the climatic contrast between the tropical and temperate zones. Yet, although this may sufficiently explain the lagging of the Monocotyledons in the tropics as compared with the Sympetalæ, it will not explain why amongst the primary groups of the Archichlamydeæ those that are most tropical, like C and D, hold the smallest number of aquatic families (Table V.).

Note on the relative proportions of "both-world" families in the tropics and in the extra-tropical regions of the northern hemisphere.

The statement on page 447 that 61 per cent. of tropical families and 64 per cent. of northern extra-tropical families occur in both the Old and the New Worlds is based on data given in Table III. Here we are concerned with families purely tropical and purely northern extra-tropical. But for the statement that follows it the data are only partially supplied in the Tables, as in IV., V., etc. It is there asserted that 69 per cent. of exclusively or mainly tropical families and 77 per cent. of exclusively or mainly extra-tropical families in the northern hemisphere are found in both the Old and the New Worlds. But to obtain these results it was necessary to eliminate the southern extra-tropical elements ; and to avoid the necessity of giving another complicated set of tables I have here given the data on which this assertion is based. They are as follows :—

The total of 153 exclusively or mainly tropical families is made up of 120 exclusively tropical and of 33 tropical and north temperate families but *mainly tropical.* (In these connections it should be stated that the tropics include the subtropics and the north temperate all the northern extra-tropical regions.) Of the exclusively tropical 73 and of the mainly tropical all occur

in both worlds. This gives a total of 106 both-world families out of a total of 153 mainly or exclusively tropical families, or 69 per cent.

The total of 62 families exclusively or mainly extra-tropical in the northern hemisphere is made up of 36 exclusively north temperate and 26 north temperate and tropical but *mainly north temperate.* Of the exclusively north temperate 23 and of the mainly north temperate families 25 exist in both the Old and the New Worlds. This gives a total of 48 both-world families out of a total of 62 northern extra-tropical families, or 77 per cent.

It is worth noting the manner in which, according to these results, the both-world families tend to congregate in the intermediate region between the tropics and the north temperate zone—that is, among the tropical and north temperate families that are mainly tropical and among the north temperate and tropical families that are mainly north temperate. Considerable importance attaches itself to the interpretation of this tendency.

Table I.

(See Explanatory remarks.)

A.—The distribution of the Angiosperms between the Old and New World.

	Primaries.		Cohorts.		Families.		Tribes.		Genera.		Species.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Old World	..	..	2	4·5	45	16·5	39	24·5	579	46	9889	52
New World	..	..	2	4·5	35	13·0	31	19·5	512	41	8874	47
Both Worlds	..	100	41	91·0	192	70·5	89	56·0	168	13	197	1
	6	100	45	100	272	100	159	100	1259	100	18960	100

B.—Compositæ excluded.

	Tribes.		Genera.		Species.	
	No.	%	No.	%	No.	%
Old World	38	26	270	51	5031	52·6
New World	31	21	169	32	4411	46·0
Both Worlds	77	53	90	17	134	1·4
	146	100	529	100	9576	100

C.—Compositæ alone.

	Tribes.		Genera.		Species.	
	No.	%	No.	%	No.	%
Old World	1	..	309	42	4858	51·8
New World	..	..	343	47	4463	47·5
Both Worlds	12	..	78	11	63	0·7
	13	..	730	100	9384	100

D.—Genera.

	No.	%
Old World	1472	46·7
New World	800	25·4
Both Worlds	878	27·9
	3150	100

Explanatory remarks.—With reference to sub-table A it may be remarked that the materials are complete for the larger groups, the primaries, the cohorts, and the families. For the tribes the matter has been sampled. In this respect the data for 23 families and sub-families were tabulated in a paper by the writer published in the 'Transactions' of the Victoria Institute for 1907. Those for 19 others have since been added, making a total of 42; and on these the results for the tribes, genera, and species are based. The volumes of the 'Pflanzenreich' series have here been used, except with the Compositæ, where Bentham has been followed. In the early paper only the tribes designated as such were utilised. In this sub-table all intermediate groupings between the genera and the family are employed under this head where it is practicable.

In sub-table B all the materials in sub-table A are used with the exception of those for the Compositæ, which are treated separately in sub-table C.

In sub-table D are given the results of an analysis made by the writer of the list of chief genera (about 3150 for the Angiosperms) that is given by Dr. Willis in his 'Flowering Plants and Ferns' for 1908. The increase in the percentage of genera common to the eastern and western hemispheres is due to the fact that the list is only concerned with "chief" genera; and it is obvious that the number of genera with limited distribution that are here excluded is very large, and would have gone far to pull down the percentage of both-world genera. Probably in a complete list of genera the percentage found in both worlds would be nearer that for the Compositæ, where the proportion is 11 per cent.; and there is therefore much to support the estimate adopted in this paper of "less than 20 per cent."

TABLE II.

Distribution of the sub-divisions of the Angiosperms in the Old and New Worlds.

					PRIMARIES.													
	Angiosperms.		Dicotyledons.		Mono-cotyledons.		Archichlamydeæ.								Sympetalæ.		Archi-chlamydeæ.	
							A.		B.		C.		D.					
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Old World	45	16·5	40	17·5	5	11·6	5	13·5	9	22·0	6	14·3	14	24·1	6	11·8	34	19·1
New World	35	13·0	30	13·1	5	11·6	4	10·8	6	14·6	6	14·3	8	13·8	6	11·8	24	13·5
Both Worlds ..	192	70·5	159	69·4	33	76·8	28	75·7	26	63·4	30	71·4	36	62·1	39	76·4	120	67·4
	272	100	229	100	43	100	37	100	41	100	42	100	58	100	51	100	178	100

Explanation.—The families are the units. The six primary groups comprise the Monocotyledons, the four parts of the Archichlamydeæ, and the Sympetalæ, the groups A, B, C, D having been formed by the writer by allotting cohorts 1–14 to A, 15–18 to B, 19–21 to C, and 22–26 to D.

Table III.

The Families of the Angiosperms distributed according to hemispheres (east and west) and to latitudinal zones.

(For the sake of comparison the results for the Cohorts are given in the last column.)

		No.	Percentage.	*Cohorts.*
Old and New Worlds or East and West Hemispheres.	Cosmopolitan	70	25·7	26 = 57·8 %
	Tropics	73	26·8	11 = 24·5
	Tropics and North Temperate	15	5·5	1 = 2·2
	Tropics and South Temperate	8	3·0	
	North and South Temperate	14	5·1	2 = 4·5
	North Temperate	9	3·3	
	South Temperate	3	1·1	1 = 2·2
		192	70·5	41 = 91·2 %
Old World or East Hemisphere.	General			
	Tropics	20	7·3	2 = 4·4 %
	Tropics and North Temperate	..	..	
	Tropics and South Temperate	5	1·8	
	North and South Temperate	2	0·7	
	North Temperate	8	3·0	
	South Temperate	10	3·7	
		45	16·5	
New World or West Hemisphere.	General			
	Tropics	27	10·0	2 = 4·4 %
	Tropics and North Temperate	1	0·4	
	Tropics and South Temperate	1	0·4	
	North and South Temperate	..	..	
	North Temperate	3	1·1	
	South Temperate	3	1·1	
		35	13·0	
		272	100	45 = 100

NOTE.—The Tropics include the Subtropics, and the Temperate zones include all extra-tropical regions. It is important to remember that the families are here treated in the mass, the small with the large. Practically all the great families would be represented in both the east and west hemispheres. The author has made a list of the principal families, those holding the largest number of genera and species. They number about 90, and at least 95 per cent. of them are found in both hemispheres. The distribution of families in the north and south hemispheres is also dealt with in different fashions in Tables VIII., IX., X.

Table IV.

Distribution of the Families and Cohorts of the Angiosperms according to climatic or latitudinal zones.

(This Table is supplementary to Table V.)

A. *Families.*

		Exclusively tropical.	Tropical and temperate but mainly tropical.	Equally shared between tropical and temperate zones.	Temperate and tropical but mainly temperate.	Exclusively temperate	Total.
Archichlamydeæ.	A	17	4	4	4	8	37
	B	15	5	4	7	10	41
	C	18	11	1	1	11	42
	D	33	7	3	5	10	58
Total		83 (46·6%)	27 (15·2%)	12 (6·7%)	17 (9·6%)	39 (21·9%)	178
Sympetalæ		14 (27·5%)	11 (21·6%)	4 (7·8%)	12 (23·5%)	10 (19·6%)	51
Dicotyledons ..		97 (42·3%)	38 (16·6%)	16 (7·0%)	29 (12·7%)	49 (21·4%)	229
Monocotyledons .		23 (53·5%)	2 (4·6%)	12 (27·9%)	3 (7·0%)	3 (7·0%)	43
Angiosperms ..		120 (44·1%)	40 (14·7%)	28 (10·3%)	32 (11·8%)	52 (19·1%)	272

B. *Cohorts.*

Angiosperms ..	10 (22·2%)	12 (26·7%)	17 (37·8%)	4 (8·9%)	2 (4·4%)	45

Explanation.—Engler's system is followed. The temperate include all extra-tropical regions, and the subtropics are comprised in the tropics. Cohorts 1–14 are placed under A, 15–18 under B, 19–21 under C, and 22–26 under D. Table V. should be consulted in this connection.

TABLE V.

The Families of the Angiosperms distributed according to climatic zones.

(In Table IV. a different arrangement of the columns is adopted for the second series.)

	Mono-cotyledons.	Archichlamydeæ. A.	Archichlamydeæ. B.	Archichlamydeæ. C.	Archichlamydeæ. D.	Sympetalæ.	Incompletæ.	Archi-chlamydeæ.	Dico-tyledons.	Angiosperms.
	%	%	%	%	%	%	%	%	%	%
Tropical	58 (25)	57 (21)	49 (20)	70 (29)	69 (40)	49 (25)	59 (23)	62 (110)	59 (135)	59 (160)
Temperate	14 (6)	32 (12)	41 (17)	28 (12)	26 (15)	43 (22)	33 (13)	31 (56)	34 (78)	31 (84)
Shared equally	28 (12)	11 (4)	10 (4)	2 (1)	5 (3)	8 (4)	8 (3)	7 (12)	7 (16)	10 (28)
	100 (43)	100 (37)	100 (41)	100 (42)	100 (58)	100 (51)	100 (39)	100 (178)	100 (229)	100 (272)
	%	%	%	%	%	%	%	%	%	%
Exclusively tropical	53	46	37	43	57	27	44	46	42	44
Tropical and temperate but mainly tropical	5	11	12	26	12	22	15	15	17	15
Shared equally	28	11	10	2·5	5	8	8	7	7	10
Tropical and temperate but mainly temperate.	7	11	17	2·5	9	23	13	10	13	12
Exclusively temperate	7	21	24	26	17	20	20	22	21	19
	100	100	100	100	100	100	100	100	100	100
Aquatics	13=30%	1=2·7%	7=17%	2=5%	2=3·5%	1=2%	3=8%	12=7%	13=5·7%	26=9·5%

Explanation of Table V.

The system of Engler is adopted, the Incompletæ of Bentham and Hooker being added for the sake of comparison. The Archichlamydeæ have been divided by the writer into four groups:—A.=cohorts 1–14; B.=cohorts 15–18; C.=cohorts 19–21; D.=cohorts 22–26. The subtropics are included in the tropics and the extra-tropical zones are classed as temperate.

The general results are given in the first series and the details in the second series. Thus it is there shown that in the first series the tropical families include those that occur also in temperate regions, but are mainly tropical, and the same with the temperate families, which include those that are mainly as well as those that are exclusively temperate. The third series deals with the aquatic and subaquatic families, concerning which other particulars are given in Table VI.

In the first series the absolute numbers are enclosed in parentheses. In the second series they are omitted, but they are given in Table IV.

By following Engler's system in the cases of the Cytinaceæ, the Cupuliferæ, and the Piperaceæ of the Incompletæ the number of families has been increased from 36 to 39 for that group.

Table VI.

Distribution of Families of aquatic and subaquatic habit in the Old and New Worlds.

	Old and New Worlds.	Old World.	New World.	Total.
Monocotyledons	11	1	1	13
Archichlamydeæ A	..	..	1	1
" B	3	3	1	7
" C	1	..	1	2
" D	2	..	..	2
Sympetalæ	1	..	..	1
	18	4	4	26

Other details are given in Table V. and the groups A, B, C, D, are there explained.

TABLE VII.

(Illustrating the proportion of Cosmopolitan families, and of families confined to the tropics of the Old World and the New World, either separately or conjointly.)

	Monocotyledons (43).	Archichlamydeæ. A (37).	Archichlamydeæ. B (41).	Archichlamydeæ. C (42).	Archichlamydeæ. D (58).	Sympetalæ (51).	Archichlamydeæ (178).	Dicotyledons (229).	Angiosperms (272).
	%	%	%	%	%	%	%	%	%
Cosmopolitan	32·6	21·6	26·8	21·4	20·7	31·4	22·5	24·5	25·7
Restricted to tropics of the Old World	9·3	8·1	9·8	2·4	10·3	3·9	7·9	7·0	7·4
Restricted to tropics of the New World	11·6	8·1	7·3	9·5	13·8	7·8	10·1	9·6	10·0
Restricted to tropics of both Worlds	32·5	30·0	19·5	31·0	32·8	15·8	28·6	25·7	26·8
Total restricted to the tropics	53·4	46·2	36·6	42·9	56·9	27·5	46·6	42·3	44·2

Explanation.—The figures in parentheses represent the total number of families in each group. In the case of the Archichlamydeæ cohorts 1-14 are placed under A, 15-18 under B, 19-21 under C, and 22-26 under D. The Cosmopolitan families have been added for the sake of convenience only. The table is used in this way. The Monocotyledons, which comprise 43 families, possess 32·6 per cent. of cosmopolitan families, 9·3 per cent. of families restricted to the tropics of the Old World, 11·6 per cent. of families restricted to the tropics of the New World, and 32·5 per cent. to the tropics of both Worlds, the general total of families confined to the tropics (including subtropics) being, therefore, 53·4 per cent. Tables IV. and V. should be referred to in these connections.

TABLE VIII.

The distribution of the Families of the Angiosperms in the North and South Hemispheres.

(Engler's system is followed. In the subdivisions of the Archichlamydeæ, as adopted by the writer, group A. holds cohorts 1–14; B. 15–18; C. 19–21; and D. 22–26. The tropics include the subtropics, and the temperate zones signify all extra-tropical regions.)

	Monocotyledons.	Archichlamydeæ.					Sympetalæ.	Dicotyledons.	Angiosperms.
		A.	B.	C.	D.	All 4 groups.			
Cosmopolitan	14	8	11	9	12	40	16	56	70—25·7%
North and South Temperate ..	3	2	3	3	..	8	5	13	16— 5·9
North Temperate..	..	2	4	5	5	16	4	20	20— 7·4
Tropics and North Temperate ..	..	4	2	3	2	11	5	16	16— 5·9
Tropics	23	17	15	18	33	83	14	97	120—44·1
Tropics and South Temperate ..	3	..	3	1	1	5	6	11	14— 5·1
South Temperate ..	..	4	3	3	5	15	1	16	16— 5·9
	43	37	41	42	58	178	51	229	272—100

TABLE IX.

The distribution of the 272 Families of the Angiosperms in the North and South Hemispheres.

Cosmopolitan	70—25·7 %
North and South Temperate	16— 5·9 %
Exclusively or mainly North Temperate	26— 9·6 %
Exclusively or mainly Tropical	139—51·1 %
Exclusively or mainly South Temperate	21— 7·7 %
	272—100·0 %

NOTE.—The Angiosperms are here treated in the mass as in the last column of Table VIII., but with a little different arrangement. All extra-tropical regions are classed as temperate.

Table X.

The distribution of the 272 Families of the Angiosperms in the North and South Hemispheres.

(The data in Table III. have here been utilised. The tropics include the sub-tropics, and all other regions are classed as temperate.)

North Temperate in varying degree	122 or 45 %
Tropical „ „	220 or 81 %
South Temperate „ „	116 or 43 %

Note.—The total number of families represented to a greater or less extent in temperate regions, that is in regions outside the tropics or subtropics, is 152 or 56 per cent. The representation in the tropics is above shown to be 220 or 81 per cent.

Summary.

From a consideration of the problems of plant-distribution, the writer is led to regard the history of the Angiosperms as resolving itself into two principal eras :—

(1) The era that witnessed the rise of the great families, a period of relatively uniform conditions.

(2) The era that witnessed the differentiation of these family types in response to the differentiation of the climatic and other conditions.

It is argued that conclusions drawn from the prevailing influences now in operation could only be applied to the differentiation of the ancient family types—that is to say, to the second era in plant-history. It is not possible, so it is held, to apply a theory based on the present to an age of other things, other ways, and other conditions. Only the hypothesis that finds its guide to the past in the abnormalities of the present can be of service to us in the interpretation of times so different.

The subject is introduced by a reference to two papers, contributed to the 'Journal of the Linnean Society,' which have an important bearing on the subject, the one by Bentham on the Compositæ, the other by Huxley on the Gentians. Then follows a statement of the differentiation hypothesis which involves the differentiation of primitive world-ranging types in response to the progressive differentiation of their originally uniform conditions. Allusion is then made to the dilemma into which all theorists fall when they come to handle the larger groups, the very persistence of which in our own age depends on the stability of their essential characters. If stable now, why so unstable then? We are thus forced to the conclusion that in the distant era

that witnessed the deployment of the Angiosperms instability prevailed. It was an age of mutations, free and unchecked, and an age of uniformity of conditions, the mutability decreasing and the modifications becoming more and more fixed with progressive differentiation of conditions, an explanation suggested by a perusal of the accounts by Dr. Willis of his prolonged investigation on the Podostemaceæ.

The distribution of families is then treated statistically; and it is shown that whilst they largely ignore the cleavage of the land into two great masses diverging from the north, they respond in a marked degree to the differentiation of the climatic zones. Behind their disregard for the present arrangement of continents and oceans lies the story of the first era, and behind their ready response to climatic differentiation lies the story of the second era. In the circumstance that the response made to the bi-cleavage of the land-mass is absent or small with the larger groups and becomes greater and greater as we go down the differentiating scale until it attains its maximum in the species, is recognised the contrast of conditions between the pre-differentiation era and the era when differentiation reigned supreme. It is held that there is a method here disclosed that could only arise by the family differentiating into the tribes, the tribe into the genera, and the genus into the species, since the opposite method of commencing with the species would produce chaos.

The paper ends with the application of the statistical treatment to the larger groups behind the families, and it is shown that whilst the Dicotyledons display a much greater tendency to detachment from the tropics than the Monocotyledons, the Sympetalæ stand foremost in this respect amongst all the groups of the Dicotyledons. It may be added that there is a large amount of material in the ten tables which from considerations of space could not be discussed. These data have therefore to tell their own story.

On a Malay Form of *Chlorococcum humicola* (Näg.), Rabenh. By B. Muriel Bristol, M.Sc. (Communicated by Prof. G. S. West, F.L.S.)

(Plates 17 & 18.)

[Read 21st March, 1918.]

I. Historical.

Chlorococcum humicola was first described by Nägeli in 1849, under the name *Cystococcus humicola*, Näg.*, as a spherical unicellular alga completely saturated with chlorophyll, except for a single lateral colourless space, and containing a single pyrenoid. He described its multiplication as being by non-motile gonidia set free by a splitting of the mother-cell-wall, but did not observe any motile cells in connection with the alga. In 1868, Rabenhorst † identified the genus *Cystococcus*, Näg., with that which Fries had described, in 1825, as *Chlorococcum*, in which multiplication by biciliate zoogonidia had been observed; and this alteration has been supported by the great majority of later botanists. De Toni ‡, however, in 1889, included the genera *Chlorococcum*, Fries (1825), and *Cystococcus*, Näg. (1849), in the genus *Protococcus*, Ag. (1824), with which he considered them synonymous. Wille's recent researches § on Prof. C. A. Agardh's original specimens in the Lund Botanical Museum show, however, that *Protococcus viridis*, Ag., is identical with the alga later described as *Pleurococcus Nägelii*, Chod., and that De Toni's diagnosis of *Protococcus viridis*, Ag., to include *Chlorococcum humicola* (Näg.), Rabenh, is quite wrong, since the formation of biciliate zoogonidia has been definitely established in this last species.

Wille shows in the same paper that the alga described and figured by Meneghini, in 1842, under the name *Chlorococcum Monas* (Ag.), Menegh. ‖, cannot be the same as Agardh's *Protococcus Monas*, because Agardh's species contains no pyrenoids, whereas, both in the description and in the figure, Meneghini lays particular stress on the clear spot in the periphery, by which only a pyrenoid can be intended. Wille suggests further that Meneghini's species was probably the same as *Chlorococcum humicola* (Näg.), Rabenh. If this is so, and it seems quite possible, Meneghini failed to observe the great variation in size of the vegetative cells, and only an examination of Meneghini's original material could prove the truth of Wille's suggestion; but, in any case, the specific name *humicola* has been

* Nägeli, 'Gattungen einzelliger Algen,' Zürich, 1849, p. 85, tab. iii. E.

† Rabenhorst, Fl. Eur. Algar. iii. 1868, p. 57.

‡ De Toni, 'Sylloge Algarum,' 1889, vol. i. p. 699.

§ Wille, N., 'Algologische Notizen,' xxii. Christiania, 1913.

‖ Meneghini, J., "Monographia Nostochinearum Italicarum." Aug. Taurin. 1842, S. 28, tab. iii. fig. 1.

in use for so many years that it must necessarily stand in preference to *Monas*.

With the exception of the observation that the fully developed cells of *Chlorococcum humicola* are cœnocytic *, no further study of this alga has been carried out, and our knowledge of the species is limited to Rabenhorst's description given in 1868. Recently, however, an opportunity has been afforded for a prolonged study of this alga, and the life-history has proved to be far more complicated than Rabenhorst's description would lead one to expect.

II. Cultures.

In October, 1915, a series of cultures was set up with a view to determining what algæ, if any, can live in soil in a resting-state, about 60 samples of soil being taken for experiment. In connection with this work, Professor G. S. West very kindly provided a specimen of soil from Kajang, near Kuala Lumpur, Malay States, which had first been air-dried and then stored in a closed specimen-tube for about two years. Three cultures were made from this soil, two in 50 c.c. conical flasks provided with cotton-wool plugs, and one in a small glass box. A sterilised mineral salt solution was placed in the sterilised vessels and about a cubic centimetre of the soil was introduced by means of a sterilised spathula. The cultures were placed under a glass jar in a north window, and left to grow at the temperature of the room.

The composition of the culture-solution was as follows, and as evaporation took place the cultures were watered with a solution of half the strength.

Potassium dihydrogen phosphate (KH_2PO_4) . .	1·0 gm.
Sodium nitrate ($NaNO_3$)	1·0 ,,
Calcium chloride ($CaCl_2$)	0·1 ,,
Magnesium sulphate ($MgSO_4$)	0·3 ,,
Sodium chloride ($NaCl$)	0·1 ,,
Ferric chloride ($FeCl_3$)	0·01 ,,
Distilled water	1000 c.c.

No growth whatever took place in the cultures until nearly eight months after their being set up, but in about the middle of June, 1916, a thin green scum appeared round the edges of the culture-fluid. This indicates that the initial temperature required for the germination of the alga-spores in this Malay soil is very much higher than that required for the germination of algæ in this country since cultures of English soils set up towards the end of November showed considerable growth by the end of April. The alga grew abundantly, forming not only a green gelatinous scum on the

* West, G. S., 'Algæ,' Camb. Bot. Handbooks, vol. i. 1916, p. 211.

sides of the vessel, but also flat green strata floating about in the liquid. Repeated examination has shown that the three cultures are unialgal cultures of *Chlorococcum humicola* (Näg.), Rabenh., and an excellent opportunity has thus presented itself of making a study, not only of the life-history, but also of the cytology of the alga.

III. The Vegetative Cell.

The ordinary vegetative cells of the alga are spherical or subspherical, and may be either solitary or collected together into small globular clusters or into flat expanded strata in which the cells are imbedded in mucus. One very important characteristic of the alga is the enormous variation in the size of the vegetative cells which make up a stratum. A great many appear to be fully grown when they have reached a diameter of less than 20 μ, while others continue to grow until a diameter of as much as 80 μ has been attained.

A vegetative cell of diameter about 13 μ shows a very characteristic structure (Pl. **17**. figs. 1–4). The wall is thin and is composed of cellulose, and it is usually of a uniform thickness throughout, though occasionally one or more slight thickenings may be seen (fig. 3). There is a single parietal chloroplast, which may take the form of a deep green layer lining practically the whole of the cell-wall with a single small colourless area on one side (fig. 2), or it may be irregular (fig. 1), having, in some cases, almost the appearance of being divided up into several smaller chloroplasts. A large pyrenoid is very conspicuous in the chloroplast, and in some cells, particularly in the larger ones, two or even as many as half a dozen may be seen, though the latter is exceptional. Starch is present in the form of minute granules scattered throughout the cytoplasm as well as in the starch-sheaths of the pyrenoids. As the cells increase in size, oil is formed and stored in the cells, so that their structure cannot be so clearly made out. In the very large cells, the chloroplast is usually continuous over the whole surface of the cytoplasm with only one, or perhaps two, perforations, and the pyrenoids are less conspicuous, the whole contents of the cell being masked by the presence of a great quantity of yellow oil and by the frequent development of a bright red pigment dissolved in the oil. When a cell has attained its full size, the cell-wall, which up to this time has remained quite thin, begins to thicken and become stratified, and a number of button-like excrescences are formed usually on the inside but occasionally on the outside of the wall. But in no case does the wall ever become thicker than about 4 μ, and the number of striations is usually few.

Stained preparations of the material were made by fixing with Bouin's solution and staining with Heidenhain's iron-alum-hæmatoxylin and with Delafield's hæmatoxylin. Comparatively little information could be obtained

from a study of the alga stained in bulk, hence the material was imbedded in paraffin, and microtome sections were cut about 5 μ in thickness.

Sections stained with Delafield's hæmatoxylin show that the cytoplasm has a somewhat reticulate structure, but that the reticulations have no definite radial arrangement; and in a few cases there can be seen an indication of a parietal chloroplast. In sections stained with Heidenhain's iron-alum-hæmatoxylin the reticulate nature of the cytoplasm is not nearly so noticeable, and the spaces between the network are seen to be filled with a granular substance. Pyrenoids, with either spherical or polygonal pyrenocrystals and usually narrow starch-sheaths, are conspicuous, there being often many in the larger cells and at least one in even the smallest cells. The adult cells are multinucleate (Pl. 18. figs. 18 & 19), the nuclei being situated at the angles of the reticulum, but they are so minute that they can only be clearly distinguished under a magnification of 1435. Then, each is seen to consist of a single small granule of chromatin, the karyosome, surrounded by a narrow but definite nuclear space which is bounded on the outside by an extremely thin nuclear membrane. The whole structure is not more than 1 μ in diameter, and even under a magnification of 2820 no further details are apparent. In very young cells there is a single nucleus exactly similar in size and structure to those of the mature cells, to which it evidently gives rise by repeated division; but the structures are so minute that it has been impossible, even in a single instance, to obtain any of the details of division.

The division of the pyrenoids usually takes place by constriction, though multiplication by fragmentation has been observed; and all the available evidence indicates that nuclear division and the division of the pyrenoids are entirely independent of one another.

IV. Multiplication by Zoogonidia.

Multiplication by zoogonidia has been observed in cells of all sizes from about 20 μ in diameter upwards. Successive bipartition of the contents of the cell takes place, with the formation of 8, 16, or an indefinite number of small oval uninucleate bodies, according to the size of the cell. These acquire cilia and swarm about within the mother-cell until an aperture appears at some place in the mother-cell-wall, when they make their way through the aperture and escape into the surrounding water. The zoogonidia produced in this way are extremely variable in size even from the same zoogonidangium, but this may be due to their being cultural forms produced under slightly abnormal conditions. Most are about 8 μ long with a breadth of about 4·5 μ, but they seem to be somewhat contractile, and many are found which are about 13 μ long and not more than 2·5 μ broad. They have two equal cilia, and are usually oval or pear-shaped, while the longer ones are

sometimes pointed at both ends. Each has a single bell-shaped chloroplast fitted against the posterior end of the zoogonidium, though in the case of a few elongated zoogonidia the posterior end was found to be colourless, the chloroplast being in the form of a parietal band round the middle of the cell. There is a red pigment-spot near the anterior end of the cell and a single pyrenoid in the chloroplast. In some cases, owing to cultural conditions, the escape of the zoogonidia was observed before the division of the mother-cell-contents was complete, and a number of extremely abnormal zoogonidia were formed ; one of these is shown in fig. 14 *d* with three pairs of cilia, three pigment-spots, and three distinct chloroplasts.

When the zoogonidia have made their escape from the mother-cell, they swim about for a short time and then frequently fuse in pairs, either with one another or with zoogonidia from another mother-cell. Two zoogonidia become entangled by their cilia and fusion takes place from the anterior end in the usual way to form a zygote having four cilia attached at the anterior end. One case, however, was observed in which the fusion took place in such a way as to produce a zygote with two cilia at each end, while in another a normal zygote was seen with a small zoogonidium partially fused to its posterior end. As a general rule, the zoogonidia were of the same size, but a few cases were observed in which fusion took place between anisogametes.

A fusion of this kind does not seem to be essential to the life-history of the alga, for a great many zoogonidia, after swimming about for some time, come to rest and develop in exactly the same way as the zygotes. The cells round off, lose their cilia, and, acquiring cellulose cell-walls, develop by gradual stages into adult vegetative cells.

V. Multiplication by Aplanospores.

In certain circumstances a vegetative cell produces non-motile gonidia instead of zoogonidia. The nuclei of the mother-cell appear to increase considerably in size and number, and each becomes the centre of a little mass of cytoplasm which forms an aplanospore. A great many are produced from a single mother-cell and they become angular by compression. In stained sections of cells about to form aplanospores the nuclei are very conspicuous and the nuclear space is seen to be finely granular with an occasional larger granule of chromatin. The karyosome is almost central in position, and may be spherical or oval, or somewhat elongated with a slight constriction in the middle. In these cells the nuclei have been observed to divide by constriction (fig. 21), and it may be that the irregularities in shape of the karyosome are preliminary stages in the division of the nucleus. The occurrence of this form of nuclear division in *Chlorococcum* is surprising in view of the fact that mitotic figures have been obtained for both of the allied

genera, *Characium** and *Chlorochytrium*†, but it points to the fact that either the conditions were abnormal or else the genus *Chlorococcum* is somewhat primitive.

The aplanospores thus produced remain enclosed for a considerable time within the old mother-cell-wall, which gradually disintegrates to form a mucilaginous stratum in which the young cells are imbedded, and the alga enters into a palmella-like condition. In this state further division of the young cells into two or four daughter-cells may take place by successive bipartition, and strata of considerable extent may be formed; but no cellulose walls appear, and the cells remain imbedded in a mass of mucilage. A sudden change in external conditions, with its accompanying physiological shock, induces the formation of cilia either at once or after one or two further divisions, and the cells, becoming motile, swim away rapidly from the mucilaginous stratum. Fusion of these zoogonidia has frequently, though not always, been observed, and develpment takes place in exactly the same way as in the normally produced zoogonidia.

The observation of this delayed production of cilia by the palmelloid cells is interesting in that it indicates that the aplanospores are really reduced zoogonidia, but that the surrounding nutrient conditions are such as to be able to support the development of a large number of individuals in a small space, and to render their wider distribution unnecessary.

The zoogonidia produced in this manner are oval and are larger than those formed normally. They vary considerably in size, being from 5 to 9·5 μ in breadth and from 9·7 to 14·5 μ in length according to the number of preliminary divisions of the cell. Each contains a single bell-shaped chloroplast lining the posterior end of the cell, and in some cases the chloroplast is somewhat irregular in thickness forming cushion-shaped projections into the interior of the cell. There is a bright red pigment-spot at the anterior end, and a single pyrenoid in the chloroplast. In certain circumstances the palmelloid cells gradually become spherical and develop into vegetative cells.

It is characteristic of this genus that true vegetative division does not take place. In some cases the contents of a cell divide into two parts, but the two daughter-cells invariably secrete new cell-walls, and the mother-cell-wall becomes converted into mucilage. The two daughter-cells remain loosely attached to one another, and, as a result of further similar divisions, small clusters of cells are formed (figs. 4–8). Multiplication of this kind, which appears to be a modified formation of aplanospores, appears to take place

* Smith, G. M., "Zoospore Formation in *Characium Sieboldii*, A. Br.," Ann. Bot. vol. xxx. no. cxix. July 1916.

† Bristol, B. M., "On the Life-history and Cytology of *Chlorochytrium grande*, sp. nov." Ann. Bot. vol. xxxi. no. cxxi. Jan. 1917.

chiefly in cells from 10 to 20 μ in diameter ; cells larger than this multiply either by zoogonidia or by the formation of numerous aplanospores.

VI. *Chlorococcum humicola* in English Soils.

Of the samples of soil taken from fifty-one localities in this country, all but two yielded *C. humicola* in greater or less quantity, showing the wideness of its distribution and the constancy with which it occurs in soil. Of the two in which it did not occur, one was taken from the Broadbalk plot at the Rothamsted Experimental Station in the year 1846, and had been kept in a dry state for nearly eighty years before being put into the culture. A similar sample of soil collected from the same plot in 1856 yielded the alga in considerable quantity, hence its absence from the cultures of the 1846 soil indicates that the limit of resistance against desiccation and of retention of vitality for *C. humicola* lies somewhere between seventy and eighty years.

In no essential features did the *Chlorococcum humicola* found in the Malay soil differ from that found in the English soils. The spores germinated far more slowly and the cells are on the whole larger than the English ones, but, even in a single culture, the variation in size of the cells is so great that no importance is to be attached to such distinctions. For the rest, the cytology and the life-history are the same, the dominant stage depending on the surrounding nutrient medium.

VII. Amended Diagnosis.

Rabenhorst distinguished the species *C. humicola* by the following diagnosis :—"Ch. strato effuso, obscure viridi pulverulento ; cellulis globosis, magnitudine variis, plerumque numerosis in familias consociatis, tegumento communi hyalino achroo circumvelatis ; cytiodermate tenui, ætate provecta subcrasso ; cytioplasmate initio dilute vel luteolo-viridi, homogeneo, demum saturate viridi, granuloso.

" Diam. cell ad 1/126‴=0·0007″.

" Propagatio fit gonidiis cytioplasmatis divisione succedanea ex ultima generationis serie transitoria ortis, e cytiodermatis abaviæ (intellige tegumentum extremum) rupturis excedentibus et examinantibus."

To this must now be added the following characters :—

"Zoogonidia aut quiescunt statimque in cellulas vegetativas augescunt aut copulatione duorum facta zygota efformant.

" Propagatio fit quoque aplanosporis plurimis (zoogonidiis redactis) in mucilagine ex solutione cytiodermatis cellulæ matricalis orta inclusis. Fieri potest ut aplanosporæ divisiones plures subeant ; postea aplanosporæ aut cilia extrudunt et se velut zoogonidia normalia præbent, aut tardissime in cellulas vegetativas augescunt.

" Contentus cellularum vegetativarum majorum sæpissime pigmento rubro obscuratur."

VIII. Summary.

The material described has been obtained from cultures of a sample of dried soil, which was sent from the Malay States about two years before the cultures were set up.

The vegetative cells are spherical or subspherical, solitary or collected together into mucilaginous strata, very variable in size, being from 20–80 μ in diameter, each with a thin cellulose cell-wall and a single parietal chloroplast containing from one to several pyrenoids and numerous starch granules. In adult cells a quantity of yellow oil is stored, in which a bright red pigment is often dissolved.

The cytoplasm is reticulate. The young cells contain a single minute nucleus and one pyrenoid, both of which multiply by repeated division so that the adult cells are cœnocytic with many pyrenoids.

Propagation takes place, by successive bipartition of the contents of the mother-cell, into 8–16 or numerous biciliate zoogonidia which may develop asexually or may act as facultative gametes. In both cases direct development into vegetative cells takes place.

Aplanospore-formation may also take place, preceded by the multiplication by constriction of the nuclei of the mother-cell. The aplanospores remain imbedded in a mucous stratum, and enter into a palmelloid state in which further bipartitions may take place. Eventually, the palmelloid cells either acquire cilia and behave as normal zoogonidia or they develop directly into vegetative cells.

True vegetative division does not take place, but the cell-contents may divide into two daughter-cells which immediately acquire new cell-walls and are set free as vegetative cells by the dissolution of the mother-cell-wall.

Chlorococcum humicola, differing in no essential particulars from that in the Malay soil, has been found to occur almost universally in English soils. The limit of its resistance against desiccation and of its retention of vitality has been shown, by investigations on long-dried English soils, to lie somewhere between seventy and eighty years.

In conclusion, I wish to express my thanks to Professor G. S. West for his valuable help throughout this work.

Botanical Laboratory,
University of Birmingham.

EXPLANATION OF THE PLATES.

Plate 17.

Figs. 1–10 and 13 × 825, figs. 11, 12, and 14 × 1435.

Fig. 1. Small vegetative cell with an irregular parietal chloroplast and one pyrenoid.

Fig. 2. Cell with chloroplast having a single small perforation and six pyrenoids.

Fig. 3. Cell with small thickenings on the cell-wall.

Fig. 4. Two daughter-cells still united by a gelatinous investment produced from the disintegrated mother-cell-wall.

Fig. 5. Small cluster of cells showing the formation of two daughter-cells within the mother-cell-wall.

Figs. 6–9. Multiplication by zoogonidia in cells of varying sizes.

Fig. 10. Empty zoogonidangium with small internal thickenings of the cell-wall.

Fig. 11. Zoogonidia of different forms. *py.*, pyrenoid; *pig.*, pigment-spot.

Fig. 12. *a–c*, Successive stages in the conjugation of isogametes; *d*, zygote with thin cell-wall before the loss of cilia.

Fig. 13. Young vegetative cells developing from zoogonidia or zygotes.

Fig. 14. *a–c*, Unusual conditions in conjugation. *a*, Formation of zygote with two cilia at each end; *b*, fusion of anisogametes; *c*, fusion of zoogonidium to posterior end of young zygote; *d*, abnormal zoogonidium set free before division is complete; *ch*, chloroplast.

Plate 18.

Figs. 15–24. Sections to show cytological characters, × 1435.

Fig. 15. Small cell stained with Heidenhain's hæmatoxylin showing reticulate cytoplasm, a single nucleus (*n.*), and one pyrenoid (*py.*).

Fig. 16. Do. showing two nuclei, a pyrenoid dividing by constriction, and a parietal chloroplast.

Fig. 17. Do. showing finely reticulate cytoplasm, with two nuclei and one pyrenoid. *a* and *b*, two drawings of the same cell at different levels.

Fig. 18. Larger cell showing more numerous nuclei and pyrenoids, and indications of a parietal chloroplast.

Fig. 19. Do. with very numerous nuclei and a number of large pyrenoids; the cytoplasm is more distinctly reticulate than in the smaller cells.

Fig. 20. Pyrenoids of various forms.

Fig. 21. Cell just before the formation of aplanospores, showing enlarged nuclei with variously shaped karyosomes. *c-n.*, nucleus dividing by constriction.

Fig. 22. Section through mass of young aplanospores. *m.*, mucous investment formed by the disintegration of the mother-cell-wall; *n.*, nucleus; *py.*, pyrenoid.

Fig. 23. Sections of cells in palmelloid condition. *a–c*, Stained with Heidenhain's hæmtoxylin; *d*, stained with Delafield's hæmatoxylin, showing the reticulation of the cytoplasm; *m.*, mucilaginous investment; *n.*, nucleus; *py.*, pyrenoid.

Fig. 24. Section of cells as in fig. 5, with pyrenoids showing distinct plates in the starch-sheath, an enlarged nucleus, and indications of a parietal chloroplast.

Figs. 25–31. Multiplication by means of aplanospores. × 825.

Fig. 25. Group of mother-cells filled with young aplanospores which are angular by compression.

Fig. 26. Mass of young aplanospores rounding themselves off from one another, within the mucilaginous envelope formed by the disintegration of the mother-cell-wall.

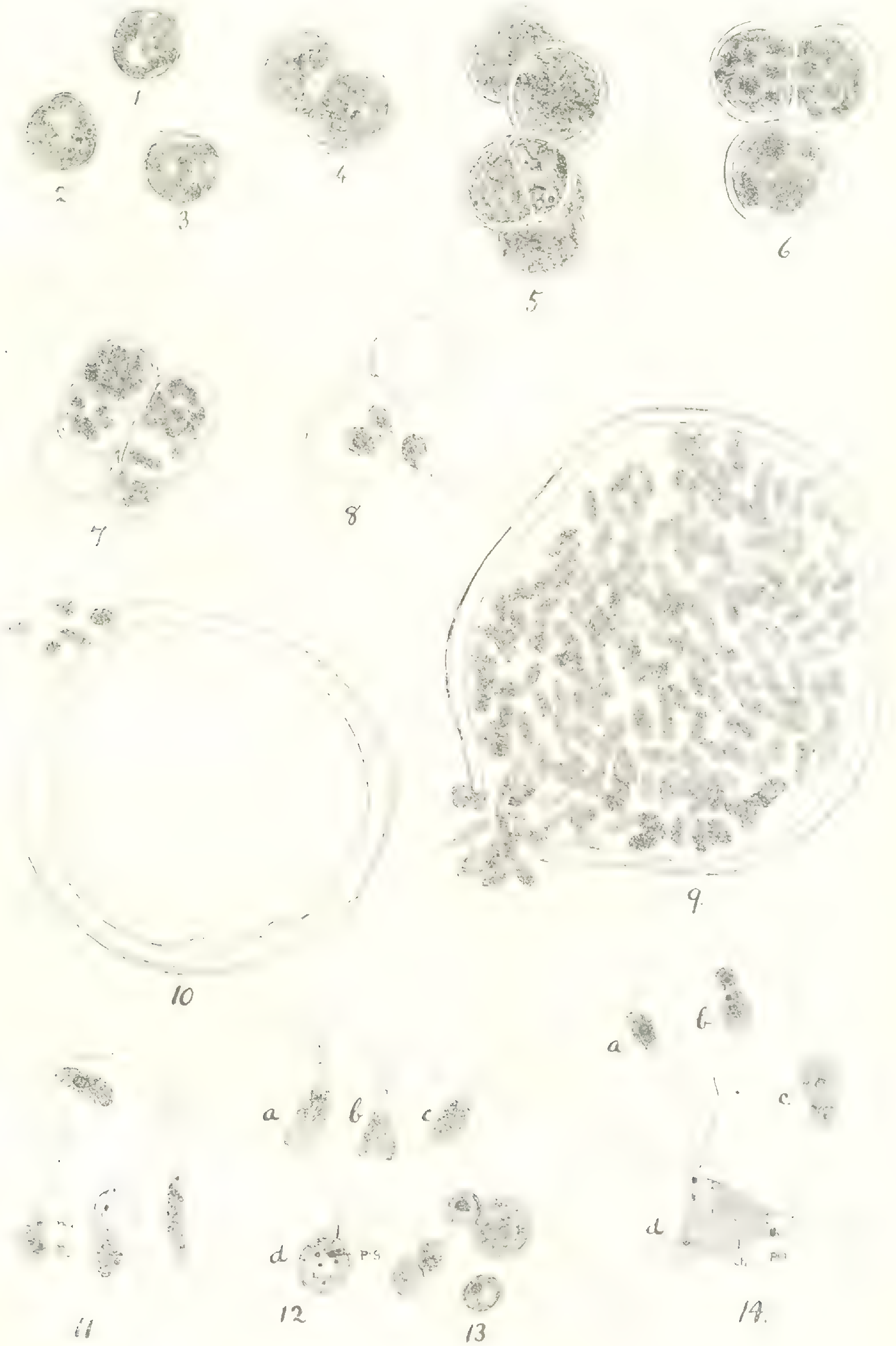
Fig. 27. Part of a mucilaginous stratum (structureless) with groups of cells formed by successive bipartitions of the aplanospores.

Fig. 28. Development of cilia by palmelloid cells after a change of medium.

Fig. 29. *a*, Palmelloid cell which has increased in size without further division; *b*, vegetative cell produced directly from an aplanospore without an intermediate motile state.

Fig. 30. Zoogonidia produced from palmelloid cells, differing in size with the number of preliminary divisions of the palmelloid cells. *pig.*, pigment-spot; *py.*, pyrenoid; *ch*, chloroplast.

Fig. 31. *a–c*, Successive stages in the fusion of these zoogonidia; *d*, zygote developing into vegetative cell.



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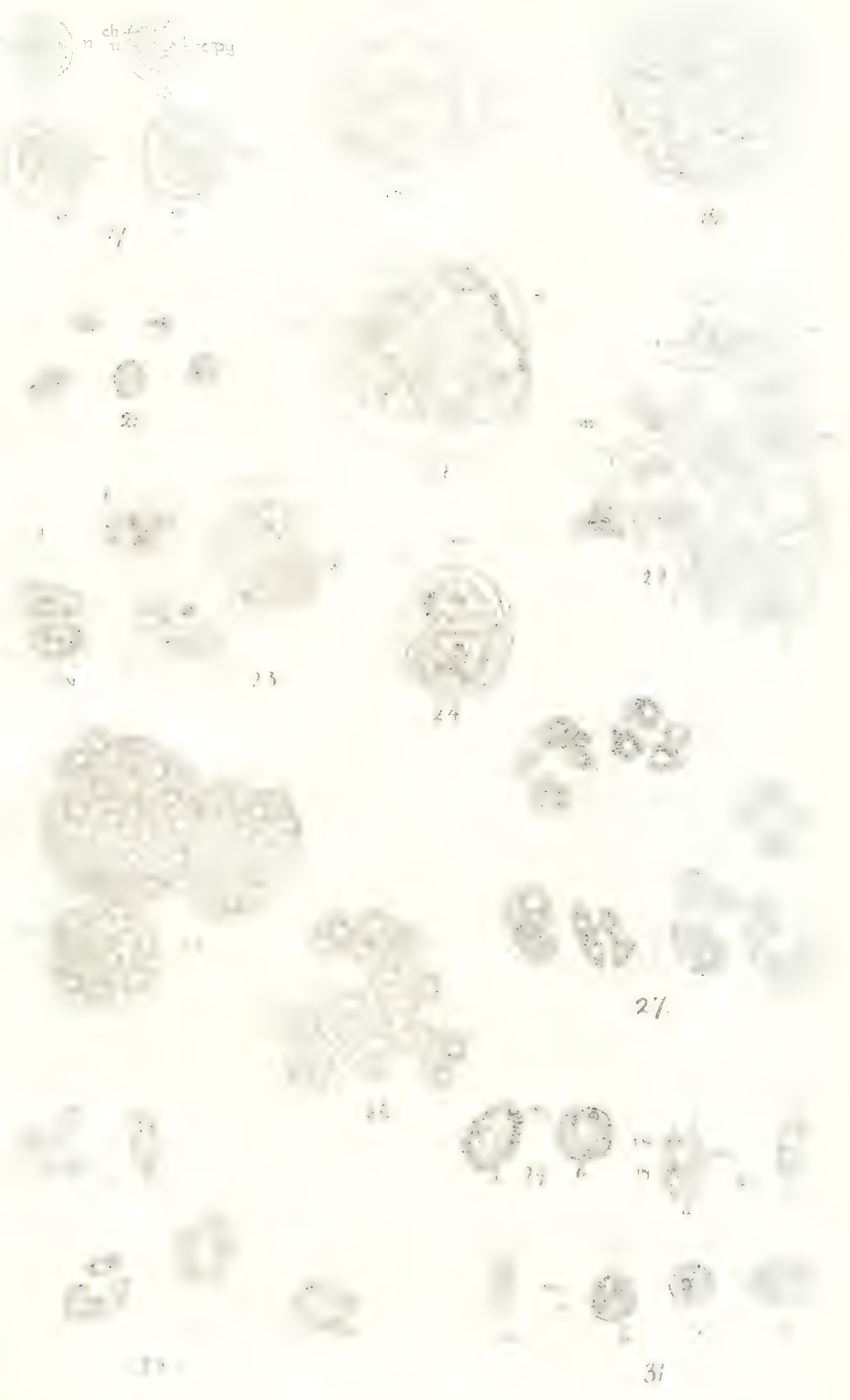
CHLOROCOCCUM HUMICOLA.



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CHLOROCOCCUM HUMICOLA.

Bennettites Scottii, sp. nov., a European Petrifaction with Foliage.

By Marie Carmichael Stopes, D.Sc., Ph.D., F.L.S., Fellow and Lecturer in Palæontology, University College, London University.

(Plates 19 & 20, and 4 text-figures.)

[Read 2nd May, 1918.]

The particular interest of the new species of *Bennettites* about to be described is mainly three-fold:—(1) It is the smallest and youngest trunk yet known; (2) it is the first European specimen to include well petrified young foliage; (3) it is well preserved, thus elucidating some anatomical details of leaf-structure in the genus hitherto not completely known from American specimens of other species. It is also suggestive of the conclusion that *Bennettites* produced detachable trunks adventitiously arising as buds comparable with those found on the living *Cycas circinalis*.

General Description.

The specimen had long lain in the British Museum (Natural History) in a number of unconnected pieces, and had been transferred without history from the Botanical Department in 1898 to the Geological Department, where it now is. The specimen, cut into four separate pieces and two slides long since, had passed through many hands and been given six different and unassociated catalogue numbers, viz., V. 4502, V. 4767, V. 4782, V. 5445, V. 5650, and V. 8423. Some of these had been associated by Mr. W. N. Edwards, of the Geological Department, British Museum.

The parts when all brought together fitted so well that there is no doubt of their forming a single specimen. There is no record of the horizon or the locality of its source.

The tiny trunk was oval in horizontal outline, and rather like a somewhat pointed pear in vertical elevation. It much resembled outwardly, both in size and appearance, a large *Williamsonia* fruit, being only about 8·5 cm. in height, and with a largest diameter of 7 × 5 cm. Text-fig. 1 gives in outline the appearance of the specimen in natural size. Long ago it had been cut across about the middle, cut (1) in the figure, and the upper piece had then been cut once vertically to this and along the shorter diameter, cut (2), and then one of these resulting portions cut again in half at right angles to this cut and along the larger diameter, cut (3). These cuts gave the large basal piece A, the half of the upper half, B, and the quarters of the upper half C and D. From these in the early days two thick longitudinal sections had been made from the faces of cuts (2) and (3).

When I began work on the specimen Dr. Smith Woodward, F.R.S., kindly allowed me to have a complete series of sections from the lower part A,

which yielded sections *m* to *r*, and also a series from the upper part B, which yielded sections *a* to *l*, see text-fig. 1, thus giving 17 sections in consecutive series. Pieces C and D are left uncut: in them there is little doubt that further young leaves are preserved.

Externally, as is roughly indicated in the diagram (text-fig. 1), the specimen showed an irregular, sheathing bract-like covering, and had a curved-in

Text-fig. 1.

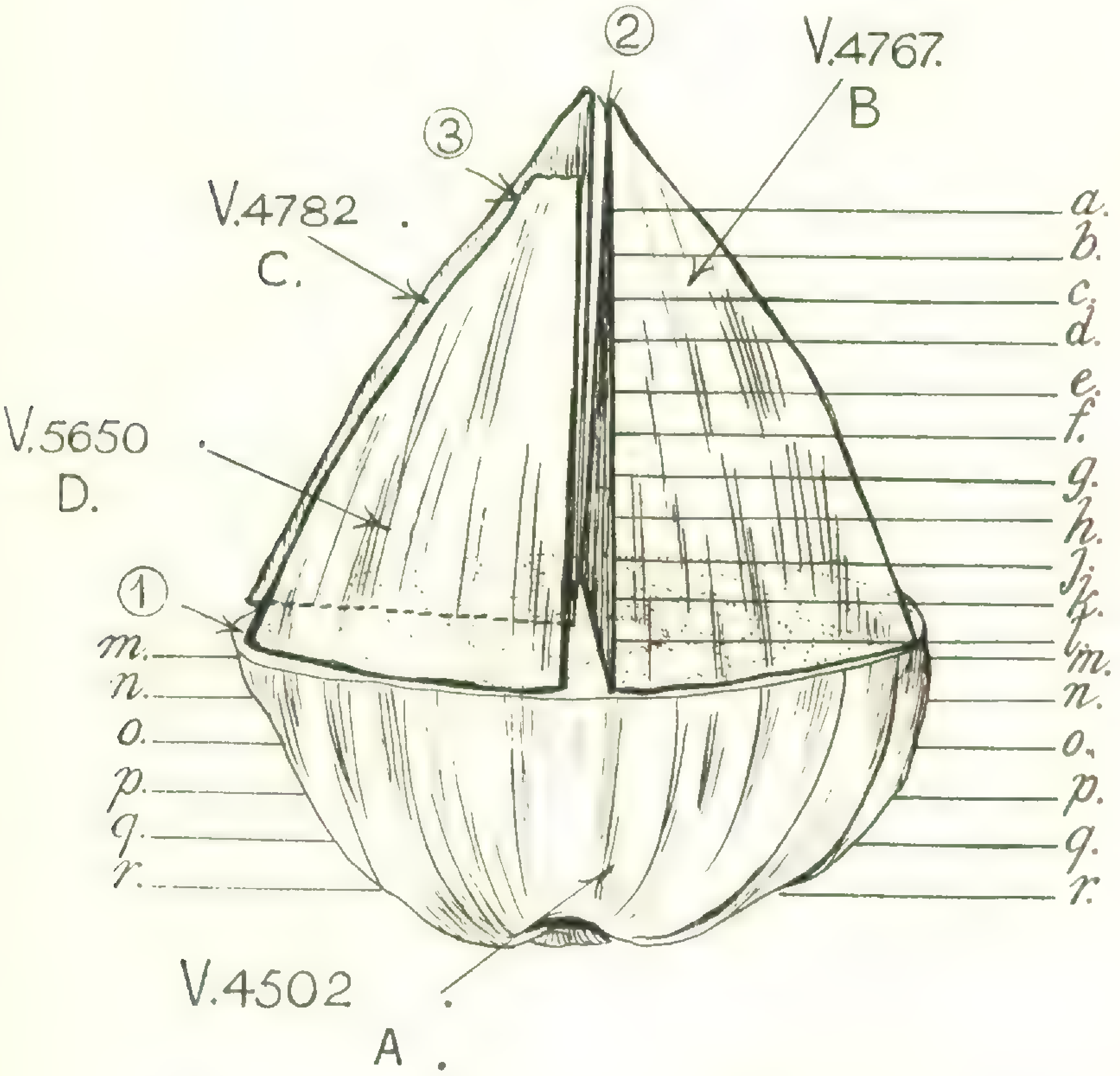


Diagram of original *Bennettites Scottii.* Description in the text.

and hollowed base like that of a *Williamsonia* fruit, though the covering "scales" were much less definitely individualised. The external appearance, however, was so far deceptive, and the specimen was not a fruit but a young trunk with its main axis surrounded only by leaf-bases, and with young leaves still folded in the bud towards the apex. This baby stem was still far too young to bear fructifications.

In cross-section the small oval axis with its ring of vascular tissue is apparent; arising from it are the numerous and closely packed leaf-bases in normal spiral sequence, see Pl. **19.** figs. 1 & 2. Above the level of section *f*,

text-fig. 1, the axis and leaf-base tissues are replaced by ramenta, but the thickly packed and definitely oriented ramenta simulate leaf-bases in a manner already noted and figured for his specimens by Wieland (1906, p. 99, text-fig. 52).

It is in this upper region that the young leaves lie in the present specimen, section *j* being the lowest section in which any of them appear. In *k*, in the leaf-base area directly below *j*, can be seen the corresponding rachis of each leaf rounding off with its horse-shoe shaped strands of vascular tissue.

The young leaves in the specimen occur as separate fronds in their normal sequence, each with the pinnæ folded as in the bud, and each frond lies above the area of the corresponding leaf-base, which had narrowed and rounded off to form the rachis in a distance of a few millimetres.

The pinnæ in some sections are closely packed together, and in the most complete leaflet there are tightly packed nine pinnæ on either side; but none of the fronds are entire, and some of the more broken or distorted leaves show as many as ten to sixteen leaflets on one side. Figs. 8, 9, and 12, Pl. **20**, show characteristic groups of pinnæ. In one instance only are the pinnæ attached to the rachis (fig. 7, Pl. **20**), most of the groups of pinnæ lie in place, but somewhat distorted in the midst of ramenta.

The ramenta are noticeably of two kinds:—large stout ones which are oriented so as to form a leaf-base shaped mass, and so to lie that with the low power they exactly simulate leaf-bases surrounding the axis; and in addition to these are the much smaller ramenta composed of as many, but individually very much smaller cells, which are packed in drifts between the others and also between the true leaf-bases.

As is usual in this family, there is no sign of a main, or indeed of any other root at the base of the trunk: the lowest section of all (*r*) has, however, a curious, nearly central ring of tissue which is discussed below (p. 486).

Detailed Description.

The MAIN AXIS.—The woody cylinder and the general outline of the stem of this young and apparently uncrushed axis is distinctly *oval* (see figs. 1 & 2, Pl. **19**), and though the original statement of Carruthers (1870) that the oval shape of the axis is a generic character has often been disputed, I think that the obvious oval of this exceedingly young specimen distinctly lends support to Carruthers' surmise.

Though this little axis is about one-fourth the diameter of the ordinary *Bennettites* trunk, its arrangements of axis, vascular strands, leaf-bases, exits of horse-shoe shaped leaf-traces and so on, are all essentially characteristic of the genus.

The *vascular cylinder* is, however, very short and proportionately thick. At its thickest part (sections *p* and *o*) the wood has about 40 tracheids in

the radius, and a zone of phloem approaching in extent that of the xylem. The radii of vascular tissue are closely ranked, and are separated by wide medullary-ray cells into the double or triple strands typical of old *Bennettites* wood. But by section *l*, the highest in which the woody cylinder is well marked before it dies out in the stem apex, the wood is reduced to about five elements on each radius.

The *protoxylems* lie in radial continuity with the secondary wood, and there are no detached groups of small tracheids such as occur in some of the Bennettitalean stems (cf. *Cycadeoidea Wielandi*, Wieland, 1906, or *Colymbetes*, Stopes, 1915).

The elements of the *secondary wood* are squarish in outline, but vary considerably in the way common in Bennettitalean wood, the average size is about $15 \times 20\ \mu$ to $25 \times 30\ \mu$. The tracheids in the higher sections are noticeably smaller than in the lower ones where the wood zone is thicker. The tracheids seem to have only the barred thickening characteristic of the family.

In a number of places the *cambium* is well preserved, as one or two thin-walled, radially narrow elements between the xylem and phloem. This is particularly good in slide *n*.

The *pith* is oval, about $1{\cdot}8 \times 1{\cdot}1$ mm. in diameter, and is composed of a mass of soft-walled tissue through which run numerous "gum-canals," as is characteristic of the family. There seem to be no isolated groups of tracheids or transfusion tissue in any part of it.

A feature of particular interest is seen in the lowest section of the series (*r*, text-fig. 1), viz. a centrally placed mass of tissue quite unusual in Bennettitalean piths. Roughly this mass is ·4 cm. in diameter, circular, and is placed in the centre of the oval of the pith. In the section above this, *q*, the differentiated tissue-mass is not present, but when the section is viewed with the naked eye some distance from a black background, a central circular area is apparent, about ·5 cm. in diameter and distinctly different in colour from the rest of the pith. Under the microscope this area is not delimited in any way, but in the central region the cells seem larger and clear, and a little more irregular than the rest of the pith, sufficiently different perhaps to account for the microscopically obvious difference in colour. A few of these cells seem to be stone cells with thick walls.

The circle of tissue on slide *r* can be seen in fig. 4, Pl. **19**, where at *s* not quite the whole circle is shown. It contains four definite zones: (1) an outer circle of very large, rather irregular cells with excessively thick walls; between the groups of these large stone cells, small, narrow cells lie rather as do medullary rays in a bast zone; there is, however, no conclusive proof that the circle is a vascular cylinder of any sort, and this appearance is probably fictitious. (2) Within this ring is a zone of two or three cells thick of narrow, thick-walled, dark cells, remarkably like a cambium,

(3) Within this is a circle a dozen or so cells thick, much more cork-like than like wood. (4) The central space within this consists of irregular pith-like tissue among which groups of thick-walled cells are visible, and of which the central portions are largely disorganised.

The nature of this curious circle of tissue is a point of interest. Its central position and large size make it evident that it is not a chance "pith-bundle" such as occur in some cycads. It might conceivably be the dying out of the cylinder of a large primary root, and it is most unfortunate that there was not material for just one section below *r* to make clear whether the tissues were carried down into a definite vascular cylinder or not. The way it dies out above makes it clear that were it a vascular cylinder it had no connection with that of the stem. Such primary roots are, I believe, not known in the cycadean cohorts.

A suggestion which has more to recommend it is that this is the upper part of a *separation layer* which, at some time, had separated this small stem from another, a parent stem, from which it may have sprouted. The erratic sprouting of seedling-like buds and their development into separate stems or lateral branches in the living *Cycas circinalis* (see Stopes, 1910) seems to offer what may be a close comparison. Were this view accepted we must look on the young stem of this new fossil as a *sproutling* and not a seedling.

While it is only wise to reserve judgment about this, it may be mentioned that, from my experience with living cycad tissues, I incline to favour the latter interpretation. Also Dr. D. H. Scott, F.R.S., who very kindly examined slide *r*, added an argument in favour of this view, saying in a letter to me, "I entirely agree with your interpretation, *i. e.* that the ring of secondary tissue round the centre is a separation layer and not vascular. I judge not only from the look of the cells, but from the fact that the tissue inside the ring is disorganized, just as would be the case if it were a separation-layer. I imagine the layer was dome-shaped and that this section cuts through the sides of the dome."

The *leaf-traces* come off from the vascular axis as single, solid arcs, with considerable quantities of tissue forming a fan ; this spreads out and breaks up into a circle of bundles as each passes directly out through the cortex into the leaf-bases in the usual way.

The *cortex* consists of a mass of large-celled soft tissue, in which run numerous "gum-canals" larger in diameter than the tissue-cells amid which they lie.

As will be apparent from figs. 1 & 2, Pl. **19**, the *leaf-bases*, though relatively small compared with the type species, *B. Gibsonianus*, are yet large proportionately to the size of the stem itself. The leaf-bases measure about 1 × ·8 cm. and are thus actually very little less than those of the full-sized trunk of *B. Allchini* (Stopes, 1915). They are of the typical rhomboidal shape and spiral arrangement. The ground-tissue and vascular bundles

show no peculiarity, but the epidermis with its thick cuticles and attached hairs is particularly well preserved. As the details of these structures have not been described for the already known species they are worth a few words in the present instance. In *B. Gibsonianus* the limiting layer of the leaf-base is described as "something in the nature of cork," and sections of the original type specimen in the British Museum show this corky layer. A thick cork layer has been more minutely described for the leaf-bases of *C. gigantea* by Seward (1897). The leaf-bases of the new species now described are still in the young condition, covered by the original epidermis. This has a very thick cuticle which forms a noticeable band of colour in the sections. One corner of one of the leaf-bases (in slide *m*) has begun to develop a multi-layered cork, and in other parts of the same leaf-base the epidermis with its thick cuticle is conspicuous.

The colour of the general petrifaction of the tissues ranges from a greyish to a vandyke brown, but the cuticle stands out from this as a clear, vivid golden-brown colour, remarkably like the cuticle of a living *Cycas*. It is not unlikely, indeed recent work in another field (see Stopes & Wheeler, 1918) causes me to think it highly probable, that here we are looking not at the mineral replacement of the cuticle, but at the actual cuticle itself, though the specimen is completely embedded in a mineral matrix as is usual in petrifactions. The cuticle is best seen in the lower regions of the leaf-bases, where it is less frequently broken by ramental attachments than it is in the upper regions where ramenta are so thickly crowded that the epidermis can scarcely be distinguished.

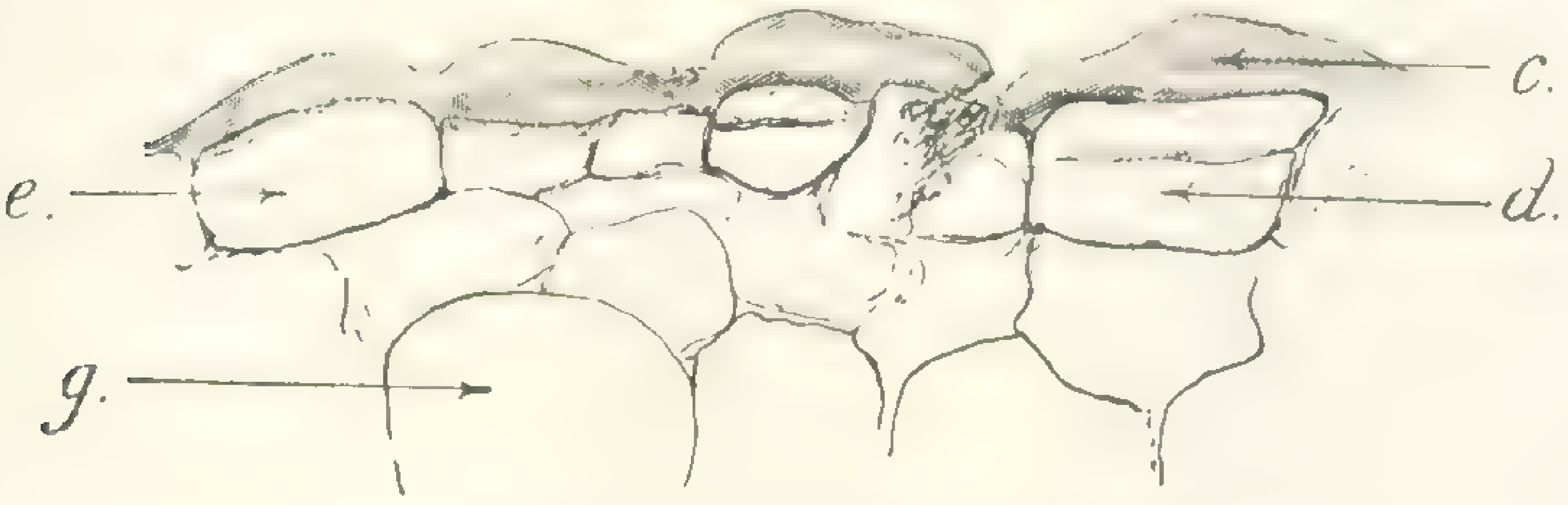
Several structures which look like stomates are to be seen in the leaf-bases, but these may be tangential cuts through the bases of ramental attachments.

The *cork layer* extends only so far as the acute corner on one side of a leaf-base, and though it is there about 18 cells thick, it abruptly comes to an end and the rest of the leaf-base, including the other corner, is still covered by the original epidermis and cuticle, with here and there a cell or two dividing. In one place the division to form the first cells of the cork cambium is particularly clear, and shows that the cork cambium of the leaf-base is *epidermal* in origin (see text-fig. 2) and thus differs from that of *C. gigantea*, which is described from much older leaf-bases as being sub-epidermal in origin (Seward, 1897, p. 28).

The *ramenta* are particularly numerous on the upper parts of the leaf-bases, where they are so crowded and are packed so closely together that they form "false-leaf-bases" which appear to the naked eye in sections exactly like true leaf-bases, as they are of the size and shape and have the same arrangement as the latter. This was illustrated by Wieland (1906, pl. 19, text-fig. 52) for his American species. The present specimen shows this feature beautifully, and also makes clear an interesting point, that in

this species the *ramenta are of two kinds*; the very large solid-walled ones which, curving round each other and packed together, form the pseudo-leaf-bases, and the interstitial ramenta, very much smaller and thinner walled, packing the spaces between the former and also between the true leaf-bases. The marked distinction between these can be well seen in fig. 5, Pl. **19**, where *b* represents about half a pseudo-leaf-base area, and *b'* part of a second, while *ir* are the interstitial ramenta.

Text-fig. 2.



Epidermis and cork cambium. See p. 496.

There are occasional doublings and irregularities in the cells, but the ramenta are generally one cell-row thick, and the small ones have approximately the same number of cells as the large ones, *i. e.* from about 12 to 20 or more. The number of cell-rows in the ramentum is, within reason, a specific character, as was pointed out by Wieland (1906, p. 52), and the present species in having a single row resembles *B. Gibsonianus* and *Cycadeoidea nigra*.

Altogether there are three types of ramenta in this plant, the two types just described and in addition hair-like ones on the undersides of the leaves themselves, which will be described below.

The rounding off of the leaf-base to form the *rachis* takes place rapidly; in section *j*, for instance, one of the leaf-bases is very definitely reduced in area, and is rounding off, while in section *h* is seen a rounded rachis with its curved horse-shoe bundle and a few pinnæ attached to it (Pl. **20**. fig. 7).

Groups of leaflets, each belonging to one frond and still folded as in the bud, lie in their normal sequence round the stem and are best seen in section *g* for example, at a level high enough up to be past the apex of the axis-tissues, which at this level are represented only by pseudo-leaf-base ramenta.

The *fronds* on the present species are clearly not adventitious, but are its normal leaves, whether or not the young stem itself had ultimately originated as an adventitious bud. Each frond is evidently still very young, not yet unfolded, the pinnules being packed in regular arrangement similar to that described by Wieland (1906, pl. 19, and 1916, pl. 58), though on a much smaller scale. The natural size of Wieland's packed group of pinnules

forming a single frond is an area roughly $1\cdot2 \times 2$ cm., while that of the present species is only $\cdot5 \times \cdot4$.

The number of leaflets in each group, *i. e.* in each single frond, is not precisely determinable because the groups are not quite complete; the most complete in appearance has 10 pinnules on either side, neatly packed and overlapping, but higher up as many as 15 pinnæ are to be seen, and this number is probably incomplete. As Wieland (1906) pointed out, the number of pinnæ in the leaves of a given species of living cycads varies so greatly that exact computations of the pinnæ in the fossil forms do not yield distinctive data. The indications are that the fronds of the present species were not only small, but had relatively few pinnæ. It must not be forgotten, however, that a species with many pinnæ like *Cycas circinalis* for example, have on the early leaves of their sprouting stems less than a fifth of the number of pinnæ present on a leaf produced in maturity.

Details of Leaflet Structure.

In a general way these fossil pinnæ are unlike those of *Cycas*, but like those of the other genera of cycads and like those fossil species described by Wieland (1899, 1906, 1916) in having a series of well marked, parallel bundles, all through the mesophyll of the leaf, each bundle surrounded by a well developed sheath and accompanying sclerenchyma. The highest number of bundles observed in one pinna in the present fossil, is 23; the pinnæ cut lower down having as few as 5 or 6. The general plan of the middle portions of the leaflets can be seen in fig. 12, Pl. **20**, and of the corners of the leaflets in fig. 11.

These leaflets, like those described by Wieland, have a strong upper cuticle and sub-epidermal tissue, and the upper differs from the lower surface of the leaflet. Beautiful as are the American specimens, all the anatomical details are not yet clear for the leaves of this family, and the present species throws some light on a doubtful feature of the leaf as described by Wieland. Details of the tissues of these leaves will consequently be given.

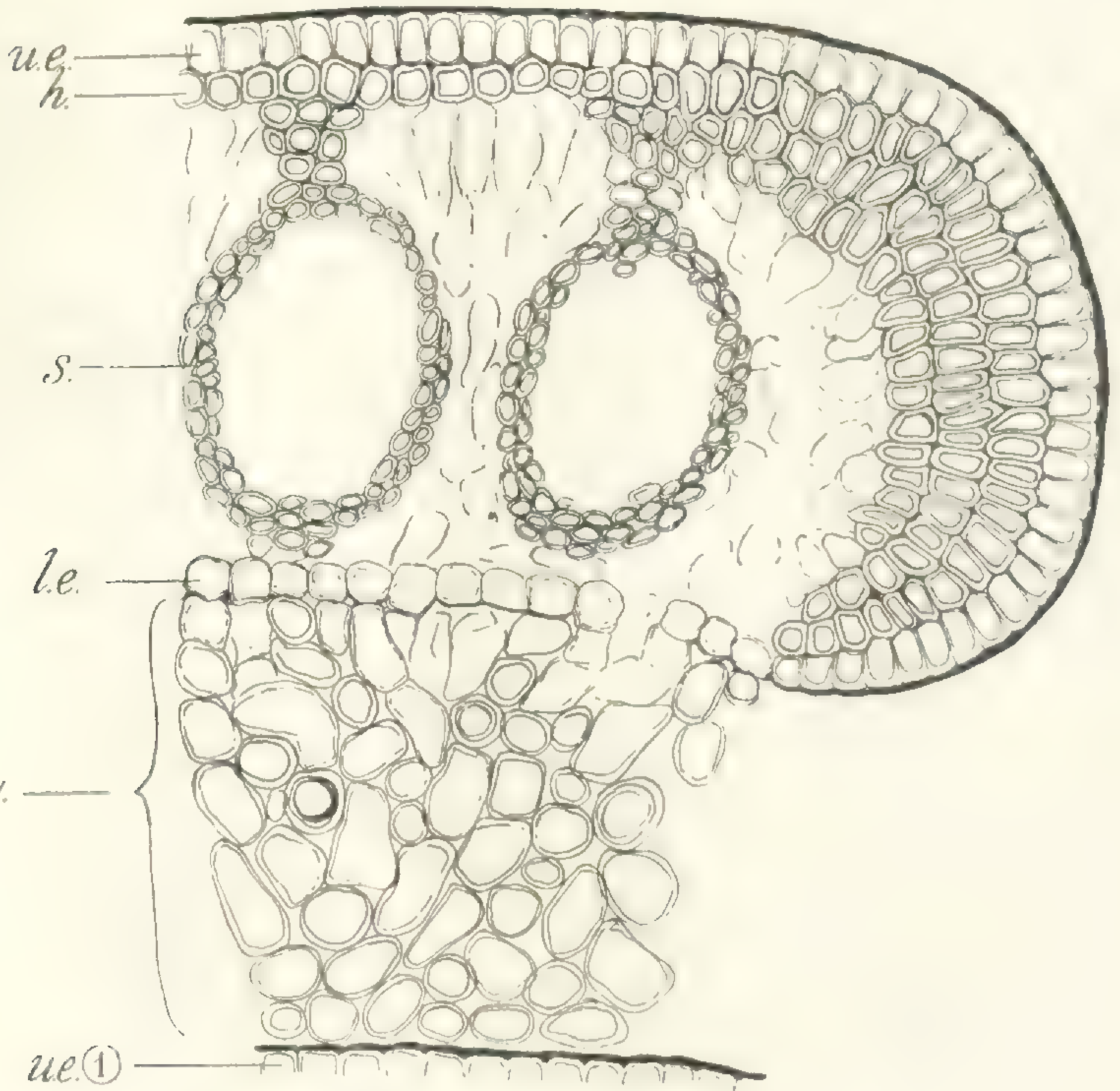
The *upper epidermis*, as can be seen in figs. 10 & 11, Pl. **20**, and text-fig. 3, is regular and well developed, with thickened outer walls and a cuticle. In the central portions of the leaflet the epidermis and the thickened tissues beneath it seem less developed than elsewhere, *cf.* Pl. **20**, fig. 12 and text-fig. 4 with fig. 11, Pl. **20**, and text-fig. 3. So far as I can observe, neither stomates nor hairs are present on the upper surface. This agrees with the generalisations of Thomas and Bancroft (1913) on the group.

Beneath the epidermis, particularly developed at the corners of each leaflet, where it is several cells thick, is a thick-walled hypoderm, see *h*, text-fig. 3, and figs. 10 & 11, Pl. **20**. A palisade seems to be slightly, but not very noticeably differentiated from the more irregular mesophyll.

I found no evidence of any transfusion tissue between the bundles or in the mesophyll.

The vascular bundles are surrounded by a definite sheath (*s.*) of two or three layers of thickened cells. This sheath is more noticeably thickened on the under side in the bundles near the edges of the leaflets. The more median bundles, and those in the middle regions of the pinnules have more delicate sheaths. A support of sclerenchyma two or three cells thick definitely connects the sheath with the upper hypoderm. As the sheath-walls were

Text-fig. 3.



Details of leaf anatomy. See p. 496.

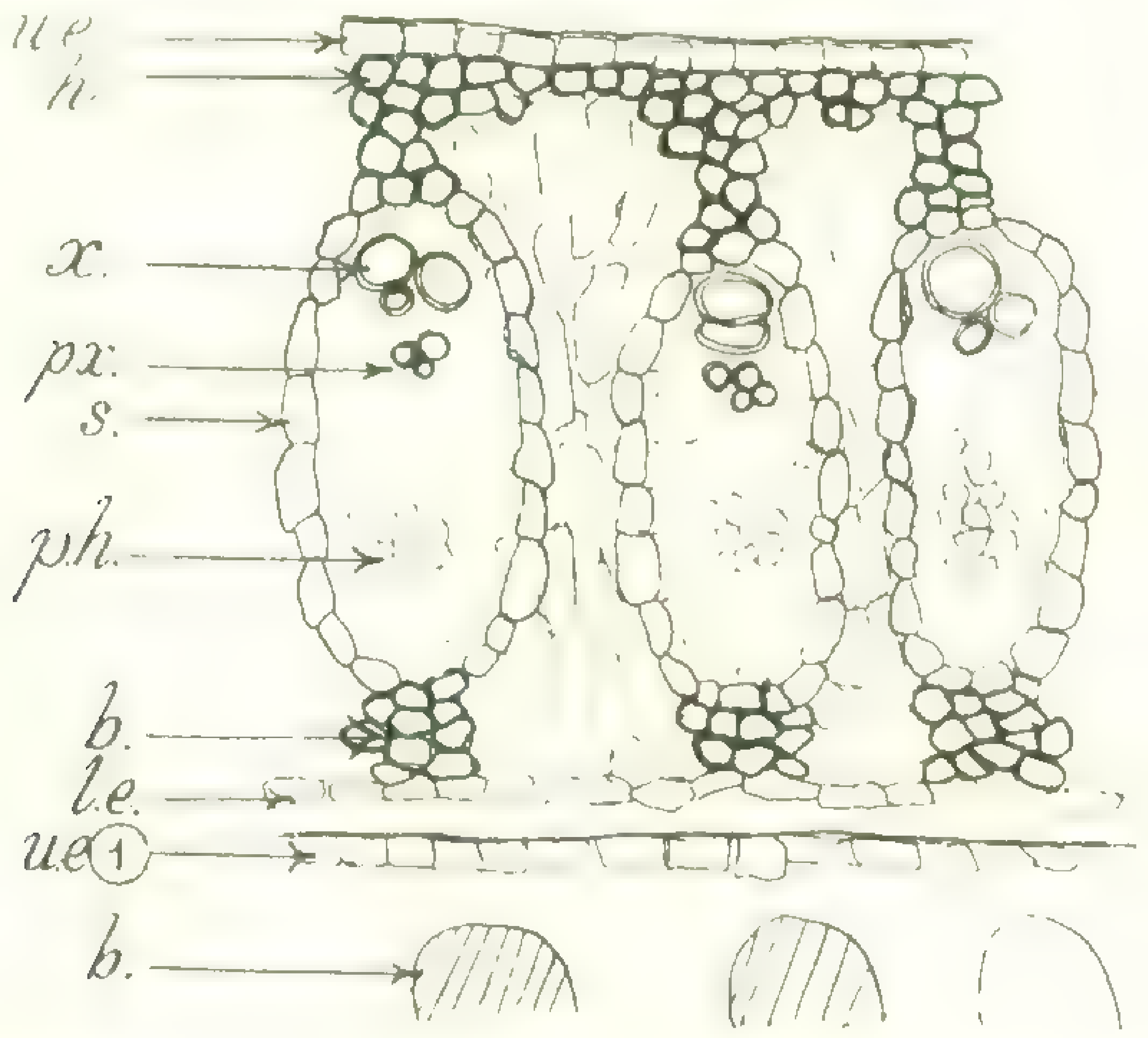
considerably thickened presumably they were pitted, but I have not been able to determine any definite transfusion-like differentiation.

The bundle is entirely centripetal, and appears to consist of two or three larger vessels and a group of protoxylems; though no bundle is perfectly preserved, several show the small wood group lying in place directly inside the sheath so that the quantity of wood was evidently small, and soft tissue, presumably cambium and phloem, occupies most of the rather large bundle space, though the greater part of this soft tissue has disintegrated.

The *lower epidermis* (*l. e.*) lies but one or two cells distant from the lower side

of the bundle-sheath. It is a definite layer, clearly to be seen, though less thickened than the upper epidermis, and broken by gaps of what may be stomata as well as being very often obscured by the thick tuft of *hairs* attached to it. These hairs invest the lower side of the leaflets in such a closely packed mass that they form what at first sight appears to be a definite tissue (see *z*, text-fig. 3, and figs. 9 & 11, Pl. **20**). The hair-like nature of the mass and some of their attachments to the lower epidermis can be seen in text-fig. 3, and fig. 11, Pl. **20**. Here and there the basal attachments to the epidermis cells can be seen, and some hairs are cut obliquely, but most run in a direction parallel to the leaf, so that in the transverse section of the leaf they are also cut at right angles to their length and present themselves as more or less circular cells. The area between one

Text-fig. 4.



Detailed anatomy of central portion of leaf. See p. 496.

leaflet and its neighbours is packed with these cells, which consequently together form much the appearance of a true tissue. This false-tissue of hairs is often about equal in area and shape to the leaflet to which it belongs, but in the middle region of the frond where the pinnules are more closely packed (Pl. **20**. fig. 12, and text-fig. 4) it is eliminated, or reduced to a very narrow zone.

Cells which seem to me to be a corresponding mass of hair-cells seem to be interpreted by Wieland (1906, p. 83) as a "lower hypoderm," a "heavy sclerenchyma region occupying all the space below the bundles," and that which he takes for a wavy transfusion tissue of a single row of cells seems to me to be really the lower epidermis. All the layer below this, as shown in the lower part of the upper half of his text-fig. p. 83, is really not sclerenchyma *within* the leaf, but is massed hairs *outside* it. The thickened,

sclerenchyma-like appearance of the hairs which apparently assisted in misleading Wieland as to their nature in his specimens, is, of course, very noticeable, and does give the mass the look of a sclerenchymatous tissue in places: however, the thickening of the ramental walls seems a well-marked feature of this plant, as a glance at the photograph fig. 5, Pl. **19**, will demonstrate.

Wieland's figure (his p. 83), with which comparison should be made, is said to be (p. 92) "extensively retouched" by himself, and the group of sclerenchyma-like cells he has drawn in what he considers the lower sclerenchyma region, were actually, I think, hairs probably similar to those of the present species.

A specific name must be given to this baby *Bennettites*, though it is not by any means impossible that some old trunk already known may be the same species. As the details of the foliage are not known for any other European form, they are really the vital points in the diagnosis. Needless to say it is very difficult to draw up a diagnosis from a single specimen, but it is a task often laid upon a palæontologist who deals in rarities.

I name the species in honour of Dr. Scott, F.R.S., to whom all palæontologists are indebted.

BENNETTITES SCOTTII, sp. nov.

The whole specimen is 8·5 cm. in height, but the stem itself is only 3·5 cm. The greatest diameter is about 7×5 cm. including leaf-bases. The leaf-bases are rhomboidal, about $1 \times {\cdot}8$ cm. Axis distinctly oval. Woody cylinder oval, at its thickest part, with a pith about $1{\cdot}8 \times 1{\cdot}1$ cm., there are 40 tracheids on the radius of secondary wood. Tracheids up to $25 \times 30\,\mu$.

Encircling the upper part, the leaf-bases round off to form rachises bearing fronds still folded in the bud. Above the apex of the stem the leaf-bases are replaced by pseudo-leaf-bases of large-celled, thick-walled ramenta.

Leaflets up to 15 and perhaps more on either side of each frond. Single leaflets with upper and lower surfaces well differentiated; cuticle and thickened hypoderm on upper side; thinner epidermis with a thick weft of attached hairs on the lower side of many pinnæ. Vascular bundles parallel, close together, from 5 to 23 in each pinna. Middle of leaflet more delicate and less hairy than the rest; the lower corners having several layers of thickened hypoderm. Vascular bundles collateral with well marked bundle-sheaths, and supporting strands of sclerenchyma. Xylem apparently only centripetal. No transfusion tissue recognised. [The specimen too young to bear fructifications.]

Summary.

A specimen cut into pieces and given a variety of numbers in the British Museum (Natural History) when pieced together and cut into serial sections proved to be a very small *Bennettites* showing well preserved structure.

Though externally the specimen was much the shape and size of a *Williamsonia* "fruit," it is a young stem with foliage still folded in the bud.

Though the stem was independent, there is evidence suggestive of the idea that this baby had originated as a "sproutling" and not a seedling. In connection with this a curious central circle of tissue in the pith of the lowest section seems best interpreted as a separation layer.

The vascular axis is very short and thick for its size, and is *oval*, though apparently uncrushed.

The leaves, with the pinnæ folded in place, are fairly well petrified, and are the first specimens of a European *Bennettites* preserved with internal petrifaction of its attached leaves. The leaf-anatomy shows a well marked differentiation between upper and lower leaf-surface, a series of parallel vascular bundles with centripetal xylem, with specialised sheaths and supports of upper and lower sclerenchyma.

A noticeable feature of many of the leaflets is the great mass of hairs, with thick walls, forming a weft of tissue-like substance, in places as thick as the leaf itself. It is now suggested that the area described by Wieland as lower sclerenchyma in his American foliage was probably formed by a corresponding hair-weft, and that his single row of "transfusion cells" was actually the lower epidermis.

There are three types of ramenta in this new species: the thick-walled, large-celled, pseudo-leaf-base forming ramenta; the small-celled, interstitial ramenta; and the hairs, composed of chains of single cells, on the lower leaf-surface.

The leaf-bases are still covered by the original epidermis with its thick cuticle, save where here and there a few cells are giving rise to an epidermal cork cambium.

The plant appears to be far too young to bear fructifications. The specimen is much the smallest and youngest member of the group of Bennettitales so far known.

It is named *B. Scottii* in honour of Dr. D. H. Scott, F.R.S.

My thanks are due to Dr. Smith Woodward, F.R.S., Keeper of the Geological Department, British Museum (Nat. Hist.) for his kindness in acceding to my request to have sections cut of the specimen; and to Dr. D. H. Scott, F.R.S., and Prof. Oliver, F.R.S., for the benefit of discussing the specimen. Also to the Government Grant Committee of the Royal Society for defraying the cost of necessary photographs.

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Explanation of the Abbreviations used in the Text-figures.

In text-figure 1 letters *a* to *r* refer only to series of slides.

In text-figures 2 to 4:—

- *b.* Band below vascular bundle.
- *c.* Cuticle of epidermis.
- *d.* Dividing cells of cork cambium.
- *e.* Epidermal cells.
- *g.* Ground-tissue.
- *h.* Hypodermal cells.
- *l.e.* Lower epidermis.
- *ph.* Phloem.
- *px.* Protoxylem.
- *u.e.* & *u.e.* (1). Upper epidermis of leaf and adjacent leaf.
- *s.* Bundle-sheath.
- *x.* Xylem.
- *z.* Zone of hairs attached to lower surface of leaf.

EXPLANATION OF THE PLATES.

[All photographs entirely untouched.]

Plate 19.

Fig. 1. Photograph of transverse section, natural size. Cut from level *m* (see text-fig. 1), showing the small axis of the trunk surrounded by leaf-bases.

Fig. 2. Photograph of transverse section about once-and-a-half times natural size. Cut from level *p* (see text-fig. 1), showing clearly the oval pith surrounded by the oval vascular cylinder of the axis, broken by the leaf-traces. Attached and associated leaf-bases surround the cortex.

Fig. 3. Photograph of the old longitudinal section of the upper part of the axis and leaf-bases, natural size.

Fig. 4. Photograph of part of the pith from the lowest section of the axis, level *r*, text-fig. 1, showing the normal tissues of the pith and also the greater part of the circle of unusual tissue, supposed "separation layer" *s*. The central cells of this circle of tissue are much decomposed.

Fig. 5. Photograph of about half of the mass of large thick-walled ramenta forming a pseudo-leaf-base area, *b*, and part of a second such, *b′*, these are separated by drifts of small-celled ramenta, *ir*.

Fig. 6. Small part of a leaf-base much enlarged, showing epidermis with thick cuticle, here appearing as a dark line *c*, broken by the insertion of a ramentum. Compare with text-fig. 2.

Plate 20.

Fig. 7. Photograph of rachis, showing its horse-shoe shaped vascular bundle. On the right a few pinnæ are attached to the rachis.

Fig. 8. Photograph of a group of pinnæ surrounded by ramenta.

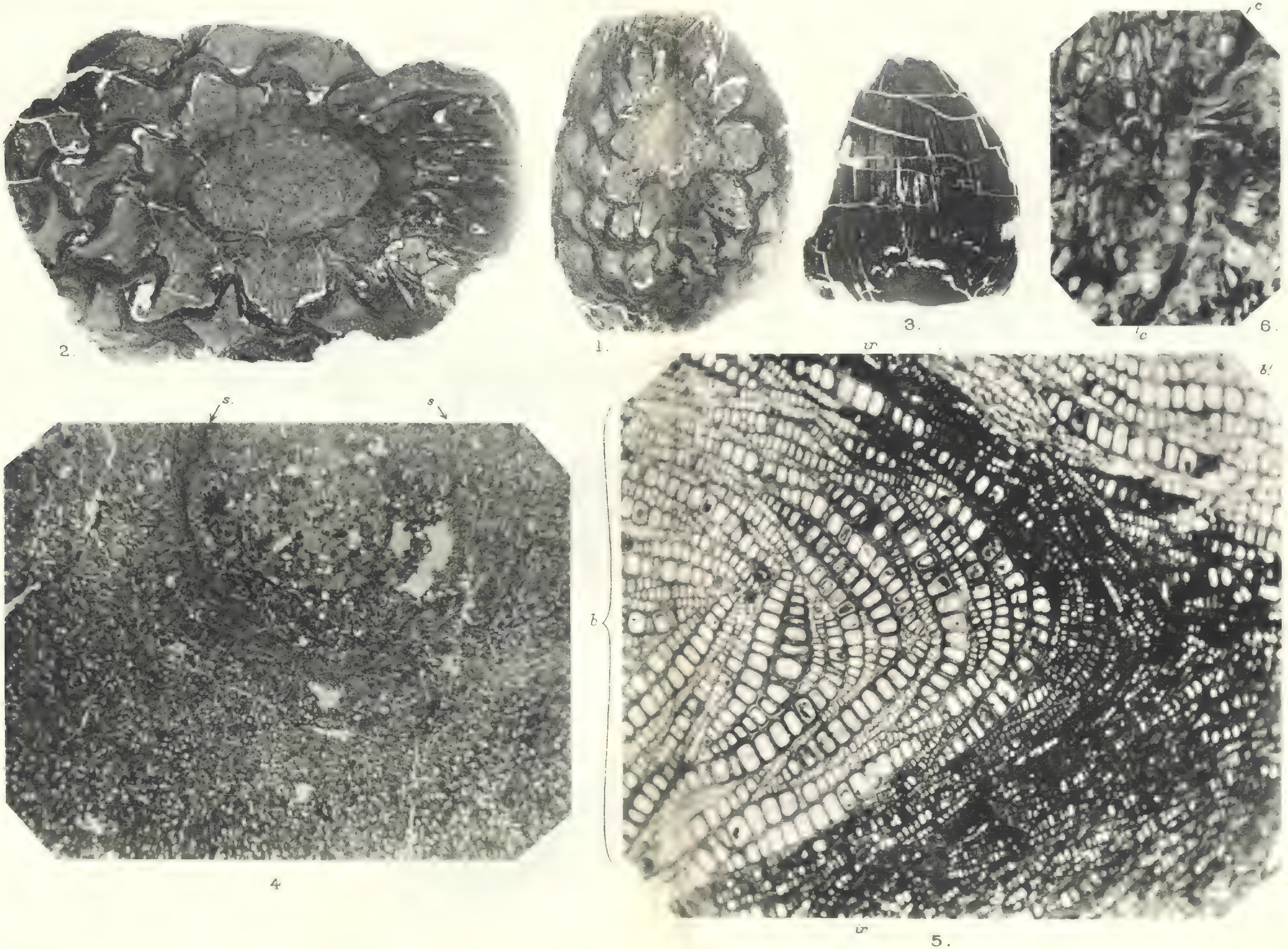
Fig. 9. Photograph of part of a similar group of pinnæ further enlarged. Between each leaflet (*l*) a zone about the thickness of each leaflet can be seen (*z*). This should be compared with fig. 11 and text-fig. 3.

Fig. 10. Photograph of corner of one of the pinnæ, showing the heavily thickened hypoderm at the corner, the bundle-sheaths, etc.

Fig. 11. Photograph of the corners of two pinnæ (*l*) showing clearly the tissue-like weft of hairs (*z*) growing from the lower surface of each leaflet and packing spaces between them about the size of the leaflets themselves. Compare this with text-fig. 3 and also with fig. 9.

Fig. 12. Photograph of part of a closely folded leaf, taken through the middle parts of the pinnæ where they have less thickened tissues, and where the pinnæ lie closely packed without the wefts of hairs between each. Note how near together the vascular bundles lie. Note also the contrast between the character of the leaflets here and in fig. 11. Compare this with text-fig. 4.

[For photographs 1, 2, & 3, Plate 19, I am indebted to the skill of Mr. F. Pittock of University College: the others I took myself.]



F.P. & M.C.S. phot.

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BENNETTITES SCOTTII, sp. nov.

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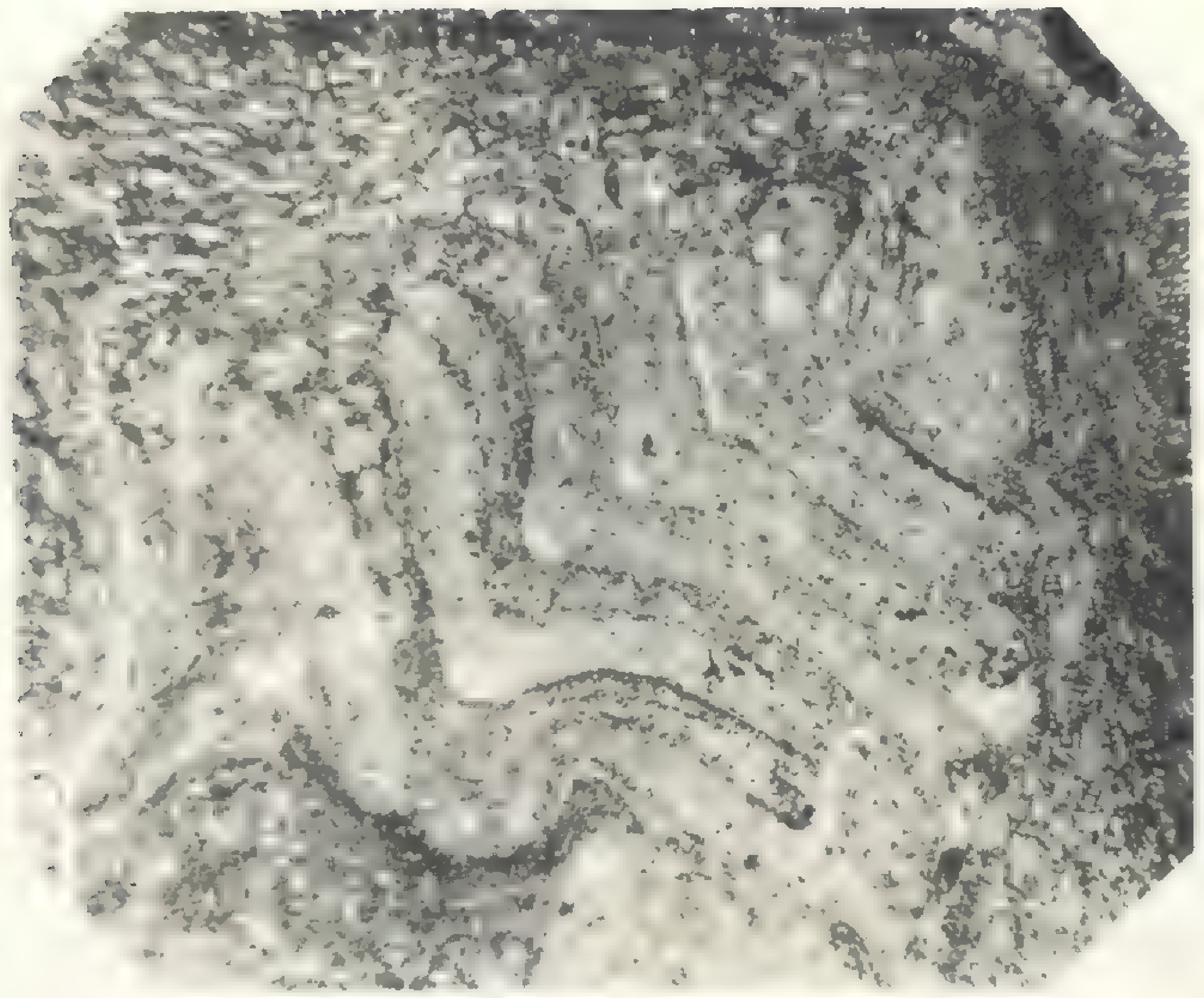

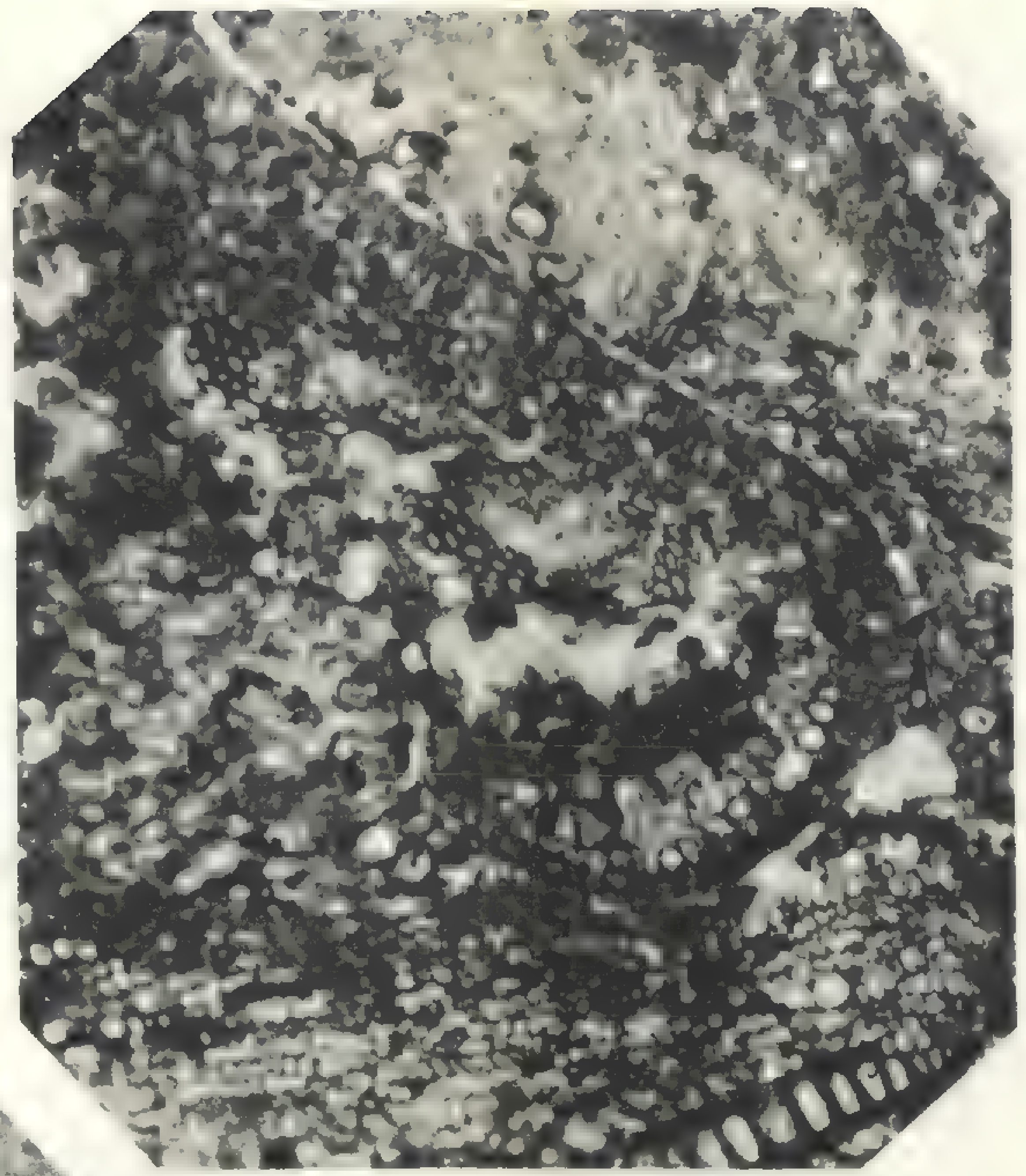

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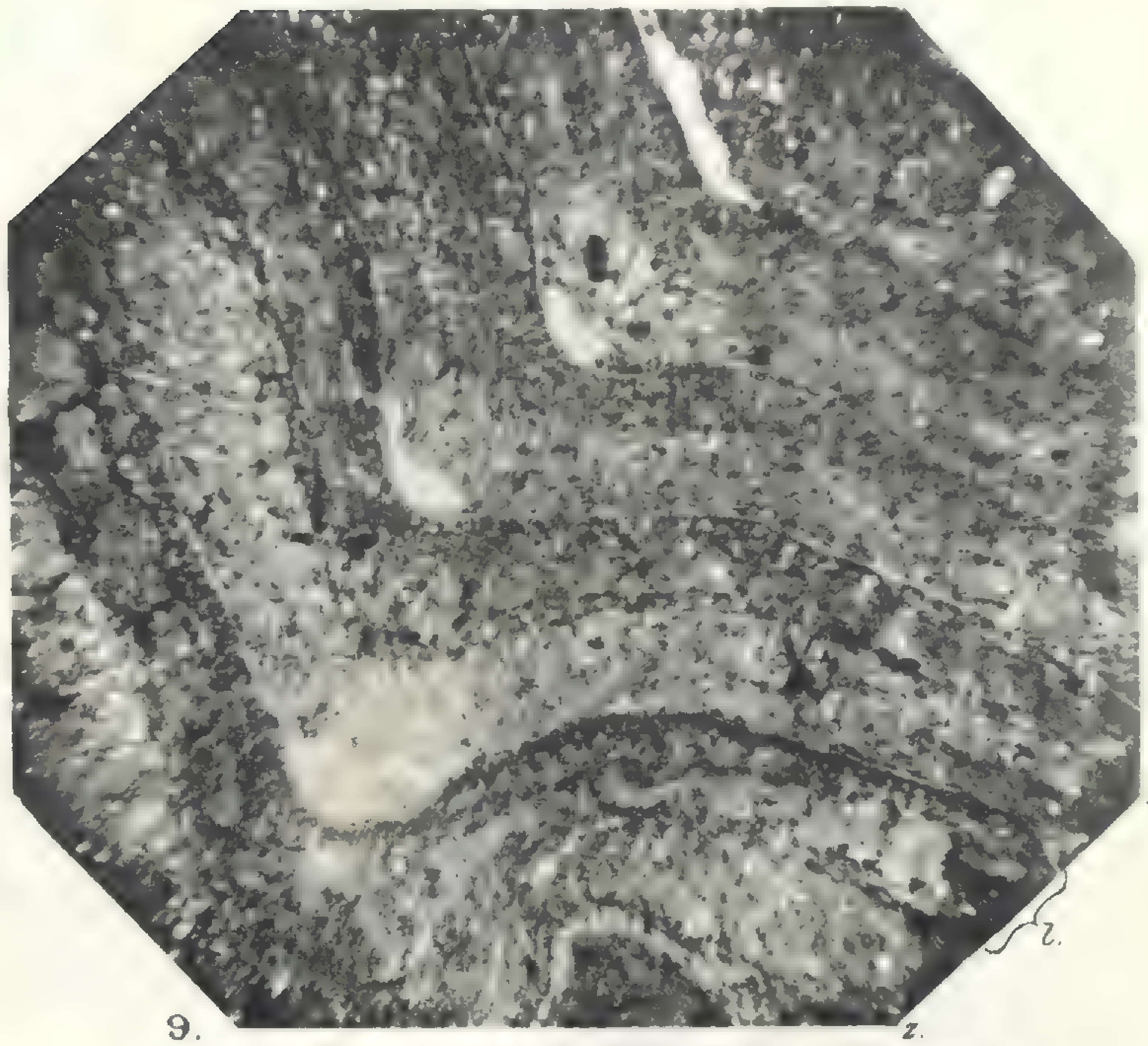

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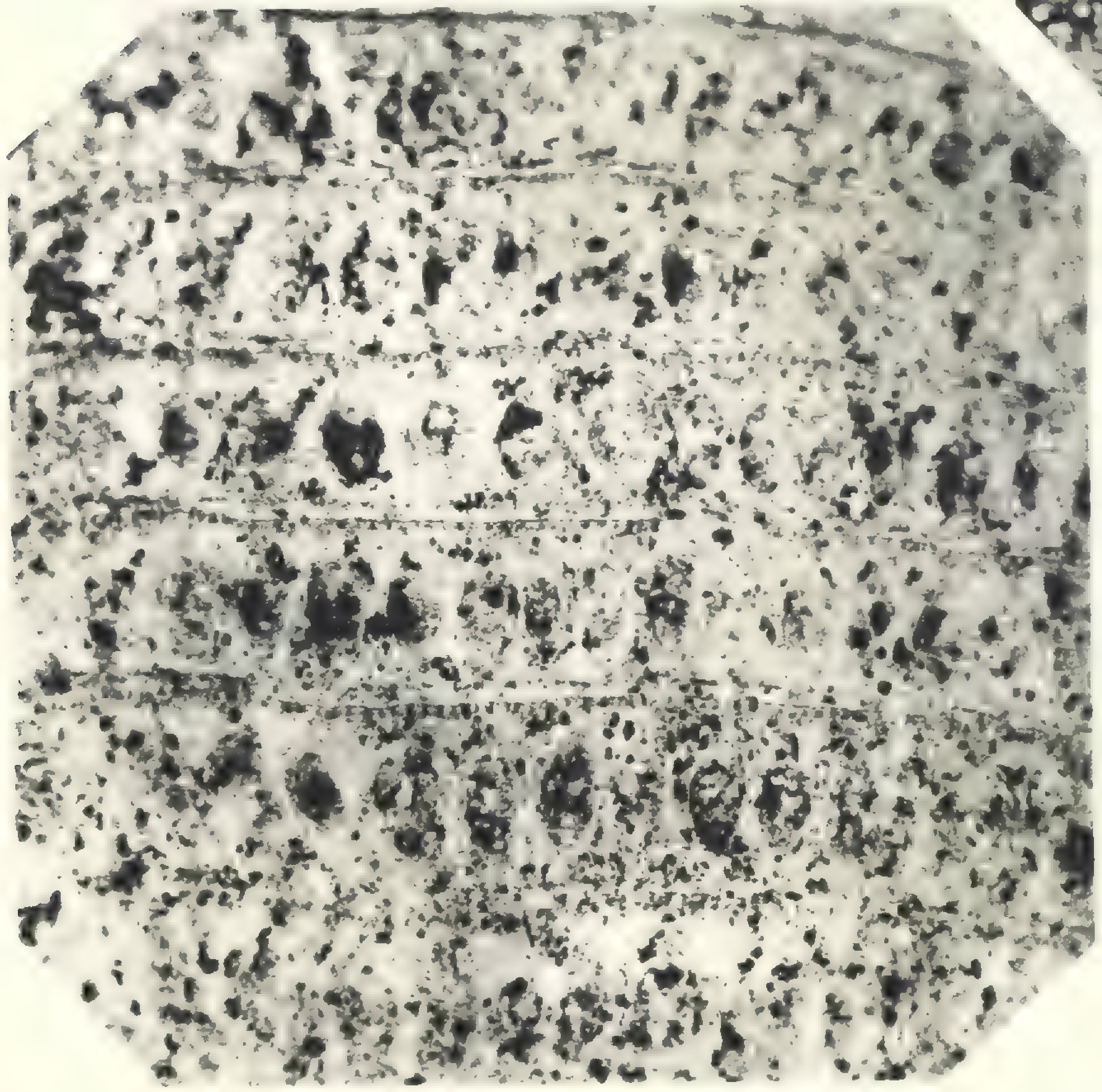

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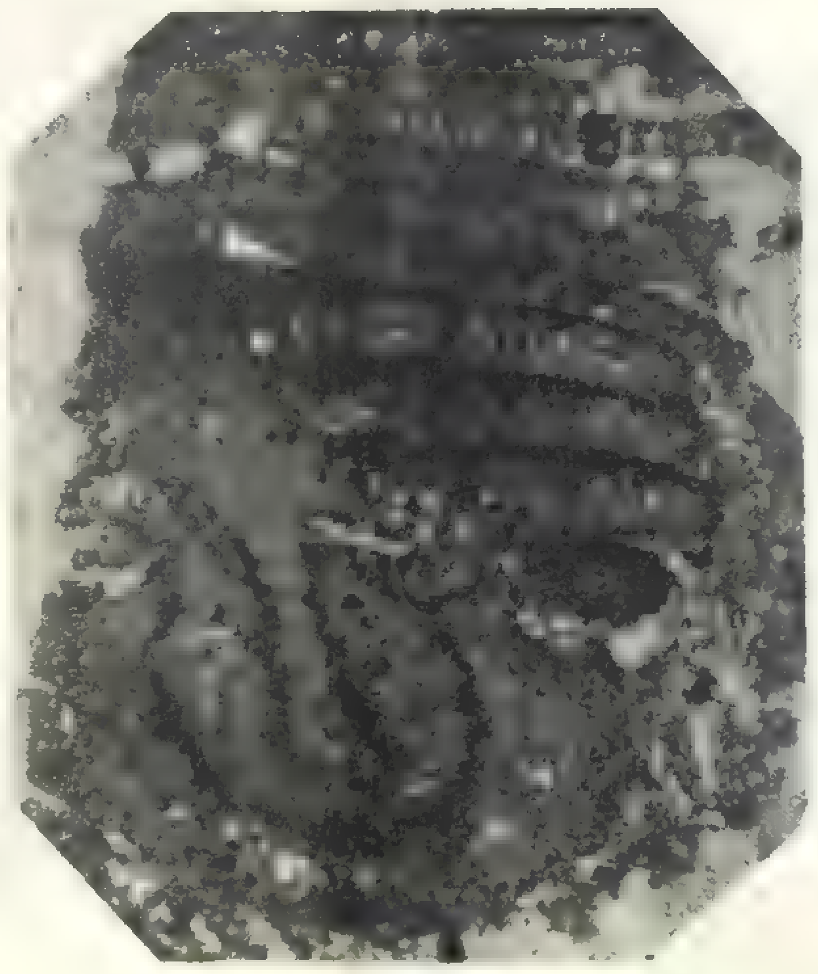

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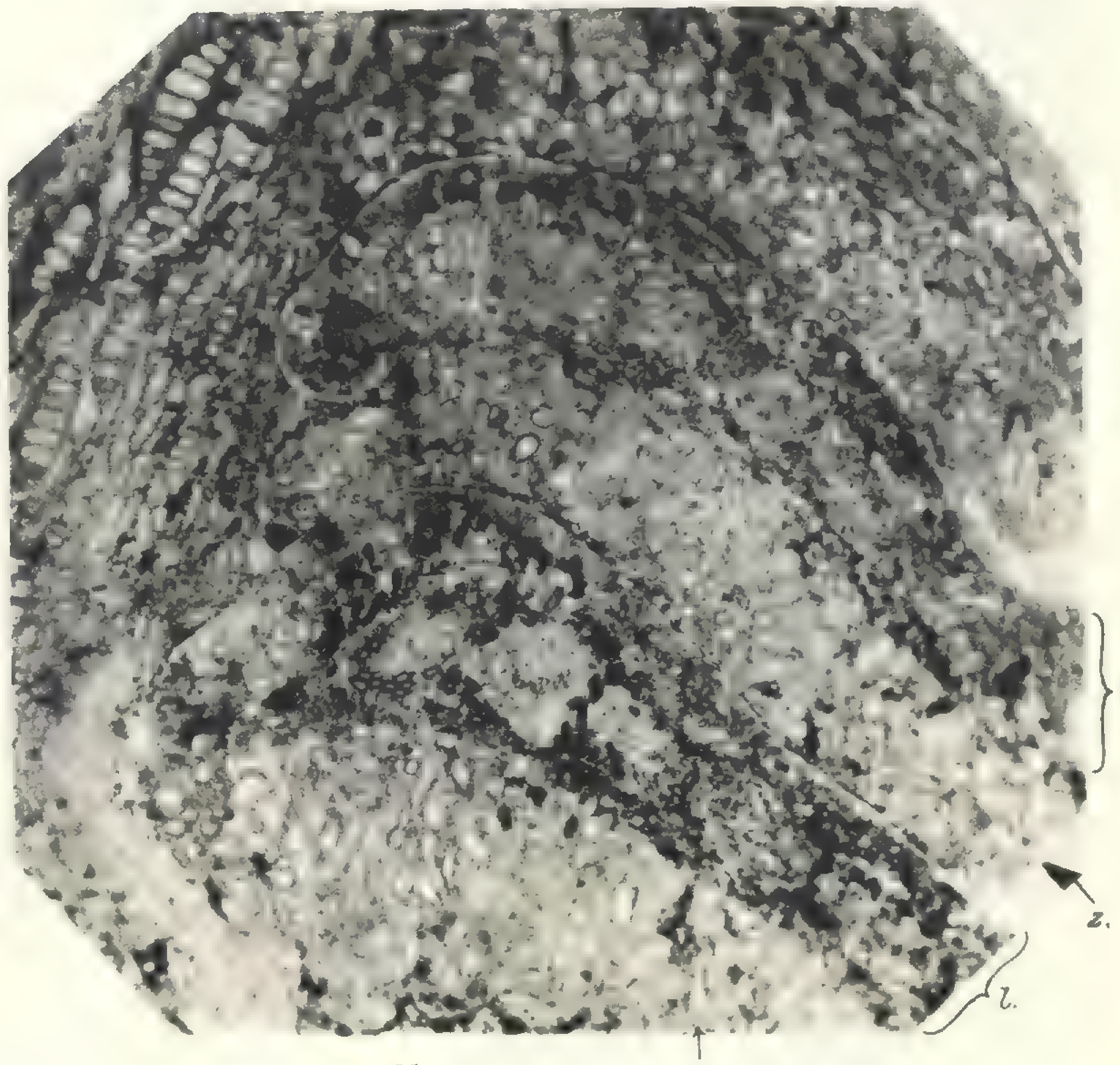

11.

M. C. S. phot. Huth coll.

BENNETTITES SCOTTII, sp. nov.

The Relation between the Alga and Fungus of a Lichen.

By ROBERT PAULSON, F.L.S., and SOMERVILLE HASTINGS, M.S., F.R.C.S.

(PLATES 21 & 22.)

[Read 6th June, 1918.]

RECENT writers on the subject of the relation that exists between the alga and fungus of a lichen have supported the view that hyphæ, functioning as haustoria, penetrate the living algal cells, and gradually absorb their contents until only empty colourless cell-walls, or walls enclosing a network of hyphal threads, remain. Upon this conclusion is based, to a great extent, the theory of parasitism on the part of the fungus, the algal cell being regarded as a helot that gains little, or nothing, by reason of the close association of the two organisms.

The literature of the subject shows a complete lack of agreement as to what takes place after the algal cell has been penetrated, or as to whether the cell is pierced at all in the living state. Hedlund (**6**) 1892 was of opinion that the protoplasm retreated, forming a concavity before the invading hyphal thread. Schneider (**8**) 1897 says, "The haustorium, after entering the cell, develops a much branched network which encloses but does not penetrate the cell-plasm." Peirce (**7**) 1899, affirms "That certainly the haustoria do penetrate the protoplasm of the gonidial cells of *Ramalina reticulata*." Elenkin (**4**) 1905, when developing his theory of endosaprophytism, concluded that "The parasitic action of the fungus haustoria on the algal cells has been more or less proved in comparatively few cases"; while Danilov (**3**), a translation of whose paper appears in the current June number of the 'Journal of Botany,' holding views similar to those of Peirce, claims to have shown, by drawings and photo-micrographs, that branches of excessively fine hyphal filaments, possibly without cell-wall, or with a wall so attenuated that it cannot be demonstrated, pierce the cell-plasm in every direction. He gives no definite information as to the frequency of penetration by hyphæ in the case of the material he used, but leaves one to infer that the condition is to be regarded as quite normal, and therefore frequent, for he bases his theory of the relation between the two organisms upon his statement respecting the hyphæ entering algal cells. On the other hand, Elfving (**6**) 1913 says, respecting *Evernia furfuracea*, "The formation of haustoria upon the hyphæ which grow into the lumen of gonidial cells, as represented in popular textbooks and described for other species of lichens, was extraordinarily rare; in my material only on a single occasion have I seen such a haustorium; while the extremely fine haustoria described by Danilov, as specially occurring in the present species, I have never seen."

The present investigation was undertaken for the purpose of obtaining

more definite information as to the frequency of penetration, if any, in some of our common lichens. For the purpose we have used as material *Ramalina calicaris*, *R. farinacea*, *Usnea florida*, *Platysma glaucum*, *Evernia prunastri*, *Parmelia saxatilis*, *P. sulcata*, *P. caperata*, *P. acetabulum*, *P. fuliginosa*, *P. physodes*, *Xanthoria parietina*, *Physcia pulverulenta*, *Cladonia pyxidata*, *C. coccifera*, *C. digitata*, *C. macilenta* and *C. sylvatica*. Our specimens were collected mostly in the Home Counties, either during the months of February and March or through the autumn months of September and October. Lichens are probably at their most active period of growth, in the south-eastern part of this country, during the early months of the year, for it has been found by us, that the process of multiplication of the algal cells is exceedingly active during that season of the year; so much is this the case, that, in growing portions of the thallus the number of gonidia undergoing change is so great that full-sized cells, in a vegetative state, are comparatively few (Pl. **21.** phot. 1).

Sections cut from fresh material were examined in water to which 5 per cent. of pure glycerine had been added, together with a small quantity of 75 per cent. alcohol. Other material was fixed either with absolute alcohol or in a chromic acid solution, prepared according to Schaffner's formula, viz., chromic acid 3 gr., glacial acetic acid 3 c.c., water 100 c.c. This latter gave excellent results with little or no shrinkage. Small portions were left in the solution for 20 to 24 hours and were then thoroughly washed in distilled water for at least 12 hours. Fixed material was embedded in paraffin and cut with a microtome in ribbons from 2 to 7 μ in thickness.

Methyl green was found to be a most useful stain for fresh material as the fungus becomes blue and stands out in contrast with the alga which remains green. For fixed material we selected Bonney's (**1**) staining medium, Haidenhain's iron alum-hæmatoxylin and cyanin and erythrocin, as differential stains.

Bonney's triple stain was tried as an experiment, for it was previously known to us as a stain for animal tissues only. Our object was to find a reliable reagent that would clearly differentiate the alga and fungus, and also show distinctly the various parts of the algal cell and the hyphal thread. With this medium the algal cells become orange-coloured, the central so-called pyrenoid (nucleus ?) reddish violet, and a small lateral body, surrounded by a light area, is stained a dark purple. The hyphal protoplasm also becomes purple. Many of the younger gonidial cells are not stained in the same manner as the mature cells; the latter, as we have already stated, become orange-coloured, while the former stain dark purple. We suggest that the difference in colour is due to the fact that the large cells are cut through when sections are made, while many of the smallest cells remain entire, and the colour which comes out so readily from cut cells, when washing the

stained sections with orange acetone, is not so easily withdrawn from those cells that are entire. This difference in coloration is also noticeable when using an aqueous solution of methyl green on fresh material for, within a few seconds, the daughter cells become bright blue, as do the hyphæ, while the older cells remain green, unless kept in the stain for several days. In this case there is no cutting of cells, they are simply teased out of the hyphal network; the older cell-wall resists the entrance of the stain much more than does the thin newly-formed wall of the young cells.

In introducing his new triple stain, 1908 (1), Bonney says: "The process is as follows:—

Solutions.

"1. Methyl violet	. . . .	·25 gramme.
Pyronin	. . . .	1·0 ,,
Distilled water	. . . .	ad. 100 c.c.

N.B.—Make the solution by heat, and filter. Label 'Methyl-Violet-Pyronin Solution.'

"2. To 100 c.c. of Acetone slowly add, drop by drop, from a drop bottle, a 2 per cent. aqueous solution of Orange G. (made by heat and filtered).

"Whilst adding the solution of the stain, keep stirring and rubbing the mixture with a glass rod. When the fluid has attained a pale yellow colour, a faint cloudiness appears. Further addition of the stain increases this until a flocculent precipitate is formed. Continue the addition of the Orange G. drop by drop, and this precipitate presently redissolves. Immediately this has taken place, filter into a bottle and label 'Orange Acetone.'

Method.

"1. Fix material in Acetic Alcohol (Glacial Acetic Acid F.P. 14·7°–15° C. 1 part, Absolute Alcohol 2 parts). Alcohol, or Sublimate Solution, Chromates and Formalin render the method useless unless subsequent to staining the sections are treated by oxidising agents.
2. Stain for 2 minutes in the Methyl-Violet-Pyronin solution.
3. Wash rapidly in water and wipe all the slide dry except the section.
4. Flood the slide with Orange-Acetone. A colour-cloud comes out. Pour off and flood again—when no more colour comes out.
5. Wash rapidly in pure Acetone, and
6. Transfer to Xylol and mount."

The whole process should not take more than five minutes, and probably less.

In using this triple stain we found the best results were obtained by a slightly slower process than that suggested for animal tissues, thus the

section remained in the Methyl-Violet-Pyronin for 5 minutes, and the whole process took about 8 minutes.

Haidenhain's iron-alum-hæmatoxylin is a most useful medium especially for bringing out the structure of the chloroplast. The so-called pyrenoid and the small lateral body already mentioned are remarkably distinct after the application of this stain.

Erythrocin and cyanin, which have been recommended for sections of lichens, differentiate the two components, but the reaction is not quite reliable. With the best results from this combination the gonidia become blue, the so-called pyrenoid dark blue, while the hyphæ take a pinkish-red coloration.

Gonidia were examined, in the first case, in sections cut immediately after gathering the specimens. They were either *in situ*, that is, in the normal position among the hyphal threads, or were slightly separated from the section while it was temporarily mounted in glycerine and alcohol. Under these conditions and after frequent washings of the entire specimen in distilled water, a small number of stray algæ were sometimes still present, but there was no difficulty in deciding which was the true lichen gonidium.

In the species of lichens enumerated above, the shape and size of the gonidium, and the shape and structure of the chloroplast and so-called pyrenoid are remarkably uniform. When saying this we do not forget that there may be considerable physiological differences in the algal cells as stated by Chodat (**2**) as the results of his culture experiments. Our investigations respecting the relationship between the alga and the fungus have, however, been strictly anatomical.

Fully developed gonidia of the lichens in question have a diameter ranging from 10 to 20 μ with an average approximating to 12 μ. They are spherical except when subject to pressure, which is especially present at the time when large numbers of new cells are being rapidly added to the gonidial layer (Pl. **21**. Phot. 1). The outer surface of the cell-wall is perfectly smooth. The chloroplast is large and differs somewhat during the development of the cell. In the daughter cell it is generally smooth in outline, but, as the cell enlarges, the chloroplast becomes very minutely verrucose. It is seldom sufficiently irregular to warrant the term stellate unless this term is employed simply to distinguish such a form from the cup or bell-shaped chloroplast which is commonly found in members of the Chlorophyceæ. Such a well marked stellate form as that figured by Chodat in the 'Monographie d'Algues en Culture Pure,' under *Cystococcus Cladoniæ*, Chod., we have not seen in the gonidia of *Cladonia pyxidata* when forming a component of the lichen.

It is quite clear that the microscopic characters of the chloroplast have not been stated with any great degree of definiteness by the older writers, and for this reason it has been not without difficulty that a decision could be

arrived at as to the exact shape of the chloroplast of the alga frequently associated with many foliose and fruticose lichens, and referred to by them as *Cystococcus humicola*, Näg.

Elfving (**5**) in describing *Evernia furfuracea*, Ach., says, "the gonidium contains a hollow spherical chloroplast cut into on one side," but the illustrations in his paper "Untersuchungen über die Flechtengonidien," 1913, do not make this "cut into one side" at all conspicuous.

There is no vegetative division of the gonidia that we have examined, but increase in their number results from the production of daughter gonidia (reduced zoogonidia), formed by the division of the protoplast into 4, 8, 16, or 32 masses. Frequent numbers are 8 and 16. Division seldom stops at 4 and rarely exceeds 16 (Pl. **21**. Phot. 1, *d.g.*). It has not been possible, so far, to follow the division of an individual protoplast, but in sections of material where the formation of daughter gonidia was actively taking place at the time of fixing, various stages, from the commencement of changes in the mother cell to the formation of the daughter gonidia, are represented. The newly-formed cells rapidly become spherical, secrete a cell-wall, develop a conspicuous so-called pyrenoid, and exactly resemble in miniature a mother cell. The wall of the mother cell is absorbed, for we can trace no rupture of the cell-wall to allow of the escape of daughter gonidia. The empty gonidial cells, which always occur in varying quantities in a lichen thallus, cannot be regarded as those from which daughter gonidia have escaped, for these latter remain in the original groups after the mother cell-wall has entirely disappeared, and it is the growth of hyphæ between and around the newly-formed gonidia that forces them apart or binds them together into irregular masses. The empty and partially empty cells are the result of the disorganization of the protoplast, but such change is not by any means due only to the effect produced by the penetrating hyphal filaments. The whole of the contents of a gonidium may be absorbed, normally, without any apparent penetration of the cell-wall. Under the conditions in which gonidia exist death frequently occurs, it would appear, owing to the great number of gonidia produced at the time of sporulation, and to the consequent crowding together and lack of air. Daughter cells are often abortive before the mother cell-wall has disappeared.

We have not found a nekral layer such as Elenkin (**4**) figures in sections of *Acarospora glaucocarpa* and *Lecidea atrobrunea*, but we have seen a relatively small percentage of dead cells after using Chlor-Zinc-Iodine, which makes them stand out very distinctly from the living gonidia and hyphæ. Danilov states that the substance in partially empty cells is fungoid, that is, it represents the fine hyphal filaments that penetrated the living protoplast and absorbed its substance. It is true that the substance within a partially empty cell sometimes stains blue immediately on the application of an aqueous solution of methyl green, as does the proto-

plasm of the hyphal thread, but this is owing to a difference in permeability of the dead and living cell-walls, for the contents of a living cell are stained similarly if left in the stain for a few days.

A large central so-called pyrenoid with a diameter of about one-third that of the cell, viz., 3 to 5 μ, is almost invariably present (Pl. **21**. Phot. 1, *n*.). It is there, in the newly-formed gonidia, at a very early stage, when the diameter of the gonidium does not exceed 2 μ. It is readily seen in gonidia from fresh material, and stains very quickly in that which has been fixed, so much so, that it becomes a prominent feature in all stained preparations except in cells about to sporulate, and in the separated masses of the original protoplast immediately after division. We regard it as the nucleus of the cell.

With Bonney's or Haidenhain's stain the so-called pyrenoid (Pl. **21**. Phot. 1, *n*.) shows a definite structure, not merely on the circumference, where it might be interpreted as being due to amyloid substance, but a structure that runs throughout the whole body and is seen in all sections in whatever direction the cut may be made. It certainly has not a distinct crystalline form such as that which is often figured.

In some sections there are cells which we have named twin gonidia (Pl. **21**. Phot. 2). It appears that two of the eight or more daughter cells, while still within the mother cell-wall, instead of secreting each its own cell-wall become surrounded by a common boundary. It does not appear probable, after the close examination of many preparations, that division of the protoplast into two portions only takes place. These twin gonidia are mostly equal or nearly equal in size, but occasionally one is normal while the other is crushed against the common cell-wall during the early stages of development and so remains quite small.

We regard the formation of daughter cells as a perfectly natural process taking place abundantly at a definite period of the year. Danilov suggests that division of the protoplast takes place after the gonidium has been penetrated, and that the change is probably an effort to ensure that some of the protoplast of the invaded cell should escape contamination by the fungus plasm. The great activity in the formation of spores at a certain definite season of the year leads us to the conclusion that the formation of spores corresponds to the similar process that takes place when isolated gonidia are cultivated upon agar-glucose and are not subjected to any excitement from fungoid hyphæ.

The diameter of the hyphal threads of lichens varies with the species, much more than does that of the diameter of the gonidia. Taking the hypha of the medulla, that part where the hypha is the least modified in the lichen thallus, we find that the diameter varies from 3 to 4·5 μ. It may be 3 μ in one species, 4·5 in another, while the mature gonidia have the same average size in both. The symbiont fungus differs, while the alga appears

to remain constant in a large number of lichens. On the upper surface, the hyphæ anastomose and become so closely welded together that the separate threads cannot be recognised, and a false tissue results (Pl. **21**. Phot. 3). The hyphæ of the gonidial layer have thin walls, they branch frequently, and are shortly jointed. These short branches, in contact with algal cells, swell out considerably into pyriform ends, and present a large surface of contact with the cells that they surround (Pl. **21**. Phot. 3). Sometimes a gonidium is attached to the end of one of the short hyphal branches and looks as if it had been cut off from that branch. The reagent Cl.Zn.I. differentiates the cell-wall of the spherical cell from that of the branch. The hyphæ of the medulla form a loose felt with abundant air spaces (Pl. **21**. Phot. 1).

We have noted two forms only of contact between hypha and gonidium: (1) when the gonidium is surrounded with loosely-applied hyphæ, "the simple contact" of Schneider, (2) the intimate contact where, by a modification in shape, the hypha presents a large amount of surface to the gonidium to which it attaches itself. Such branches are known as extra-cellular haustoria. We have not found a case that could be regarded as definite hyphal penetration of a living cell by intra-cellular haustoria. From this it follows that the occurrence of fine gelatinous filaments, protruding from a penetrating hypha and forming a network surrounding and even penetrating the chloroplast, have not been seen, consequently we are unable to accept any theory based solely upon their existence. Cases sometimes occur which resemble a network of threads around the chloroplast. The appearance is due occasionally to plasmolysis, and can be produced by placing sections of fresh material in pure glycerine. The beautiful reticulation of the cytoplasm (Pl. **21**. Phot. 2) also produces the appearance of a network of threads under certain conditions of the microscopical illumination of the object.

It has already been mentioned that the mature chloroplast is a spherical body covered with minute verrucose protuberances. A minute object with such a structure is likely to give rise to the formation of a defective image if the illumination from the substage condenser of the microscope is not perfectly centred, and when there is a misprision of focus. A defective image may also be produced by using a smaller cone of light than that required by the numerical aperture of the microscope objective in use. The defective image in each case gives more or less the appearance of threads passing over the chloroplast.

The condition of the protoplast of the gonidium, just previous to the formation of spores, presents features that are difficult to explain, but no penetrating hyphæ have been found in such cells.

With the microscope alone it is extremely difficult to decide even the family of the Chlorophyceæ to which the green spherical gonidium, common to a large number of lichens belongs, and as we have not attempted to carry

out the culture method, we present the result of observations based alone upon the microscopic image.

West (9) says: "A few of the *Chlorophyceæ* have become constituents of the thalli of many lichens . . . . It is mostly one or two of the unicellular and colonial members of the *Protococcaceæ* which are thus found." In the same work he states "*Chlorococcum*, Fries, 1825 [= *Cystococcus*, Näg., 1849]," so that the name so long associated with the gonidia of lichens is now *Chlorococcum humicola*.

As a result of the present investigation, we have arrived at the conclusion that the gonidium of the lichens mentioned in this paper is most probably a species of *Chlorella*, and that the daughter gonidia are reduced zoogonidia. West (9) suggests that this is not unlikely the explanation of the similar form of reproduction in the case of free *Chlorella*. We do not attempt to name the species that forms the algal symbiont, but it is perhaps worth noting that the mature gonidium of the lichens already referred to has a greater diameter than that of a free cell of *Chlorella vulgaris*, Beijer., and that during the formation of daughter gonidia, the number of such produced within the mother cell of the lichen gonidium is larger than the number formed in the free cell.

There is reason for concluding that *Protococcus viridis*, Ag., forms the gonidium of very few of the common British fruticose and foliose lichens, for we have not met with any vegetative cell-division whatever among the gonidia of the material that we used.

While engaged on that part of our work that required magnification of from 800 to 1000 diameters, we have used a Zeiss 2 mm. achromatic oil-immersion objective with an achromatic oil-condenser.

The photographs were voluntarily prepared for us by Mr. J. H. Pledge, F.R.M.S., who had at his disposal, by permission of the management, the whole of the apparatus of the physical laboratory of the Kodak Company's factory at Harrow. He employed a Leitz 2 mm. apochromatic oil-immersion objective, a Beck oil-immersion condenser, Watson "Holos" oculars, ×5, ×10, and sometimes a Zeiss ×2 projection eyepiece. Colour screens were used to accentuate or suppress certain details of the preparation. We gladly avail ourselves of this opportunity for expressing our indebtedness to him for the skilful care exercised in the production of the photo-micrographs.

We take this opportunity of thanking Professor G. S. West, who most generously gave us advice and kindly examined some of the preparations from which the photo-micrographs had been taken.

Summary.

A summary of the investigation may be made by reference to *Cladonia digitata*, var. *denticulata* Ach. = var. *monstrosa* Nyl., the lichen which has been used as material for many of our preparations,

1. The gonidium is spherical except when subject to pressure from other gonidia. The diameter of fully developed cells ranges from 8 to 15 μ.

2. The chloroplast, in the mature gonidium, has a slightly uneven surface.

3. After fixing and staining, minute reticulation of the cytoplasm is evident.

4. The so-called pyrenoid (nucleus) is large and central and exhibits a distinct structure throughout the substance. Its diameter is roughly one-third that of the chloroplast.

5. A small lateral body surrounded by a light area stains darker than the so-called pyrenoid; it is very conspicuous in many of the preparations; it probably represents the centrosome.

6. Twin gonidia frequently occur.

7. There is no vegetative cell division of the gonidium.

8. The increase in the number of gonidia results from the formation of daughter gonidia, autospores (reduced zoogonidia).

9. We have seen no penetration of gonidia by hyphæ.

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EXPLANATION OF THE PLATES.

Plate 21.

Phot. 1. *Cladonia digitata.* Transverse section of a squamule of the thallus showing gonidia in various stages of development.

n. Nucleus, surrounded by the chloroplast. On the circumference of the latter is a darkly stained body, probably the centrosome. The cell-wall is indicated by a faint line against which are the cut ends of the hyphæ.

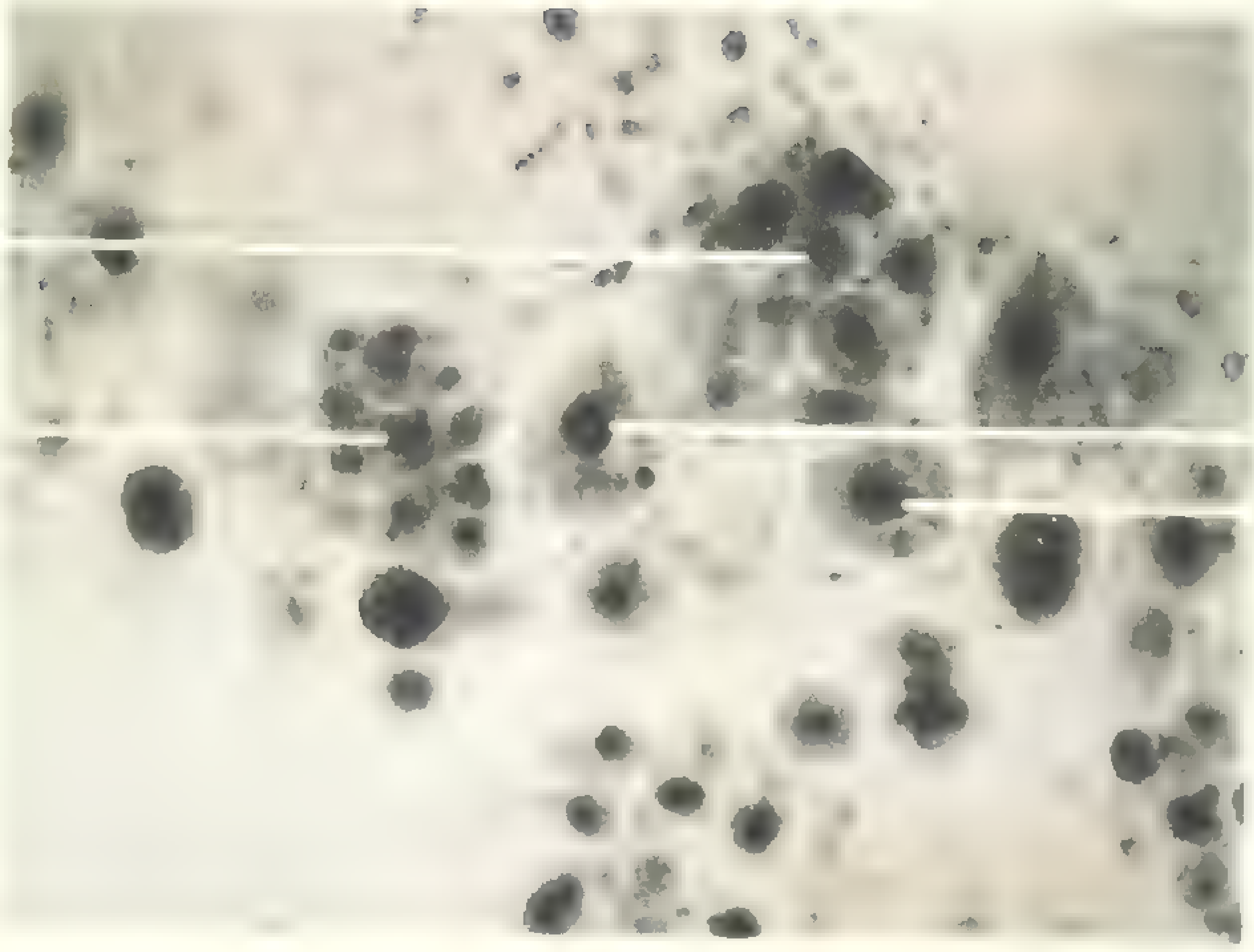
dg. Group of daughter gonidia. ×1000.

Phot. 2. Section as in the above. Twin gonidia with common cell-wall. Note the reticulations of the cytoplasm. The cell-wall is indicated as in Phot. 1. × 2500.

Phot. 3. *Cladonia pyxidata.* Transverse section of a basal squamule showing part of the gonidial layer with pyriform ends of the hyphæ closely attached to gonidia; they are the extra-cellular haustoria. × 1000.

Plate 22.

Phot. 1, 2, 3 & 4. *Cladonia digitata.* Transverse section of a squamule of the thallus showing a portion of the gonidial layer next the medulla. The photographs exhibit four planes of the same section of different depths. On the left is a mature gonidium in a plexus of hyphæ, on the right a group of daughter gonidia being surrounded by hyphæ. × 1000.



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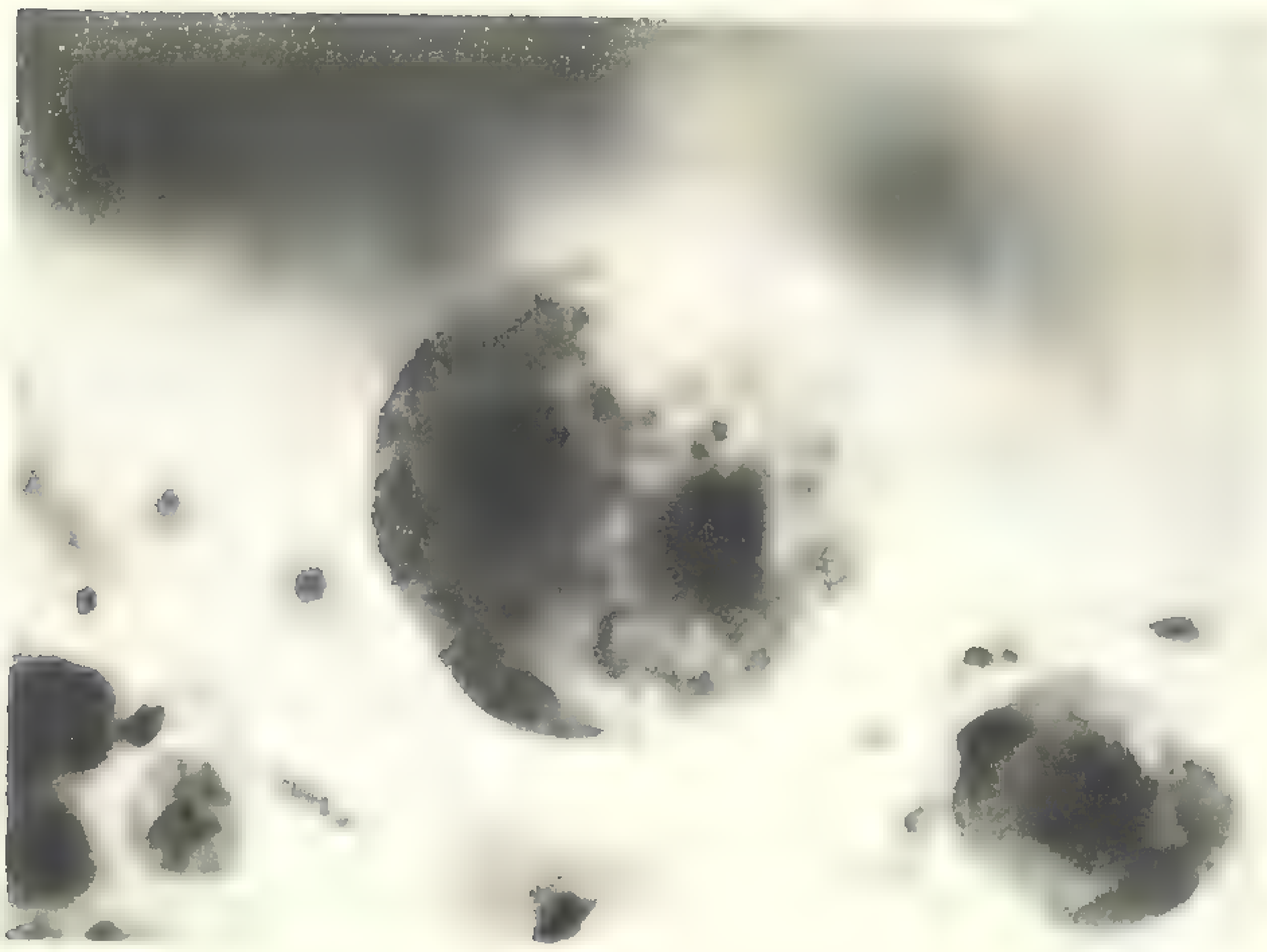

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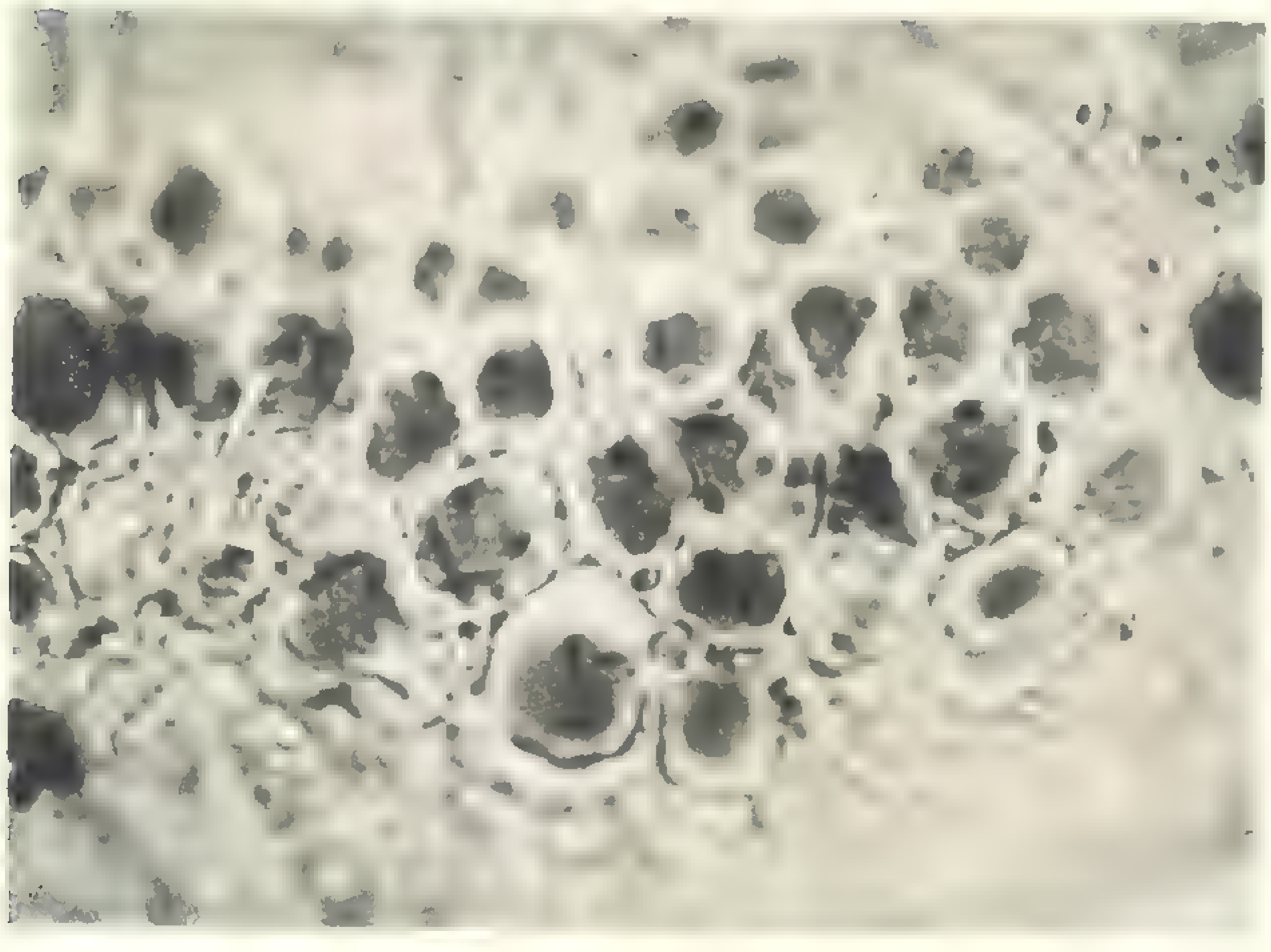
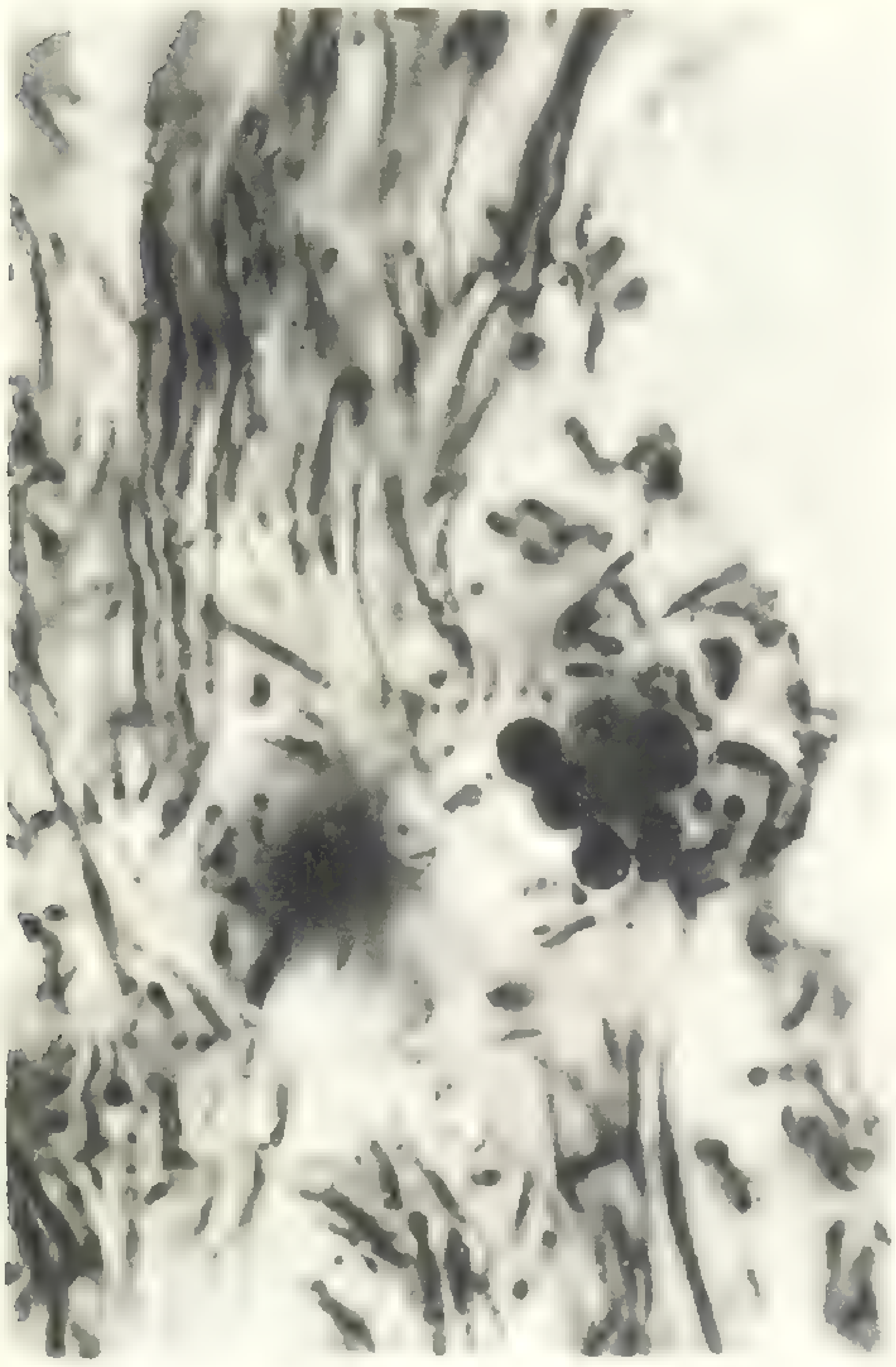


J H Pledge Phot

3

1 & 2 CLADONIA DIGITATA 3 CLADONIA PYXIDATA



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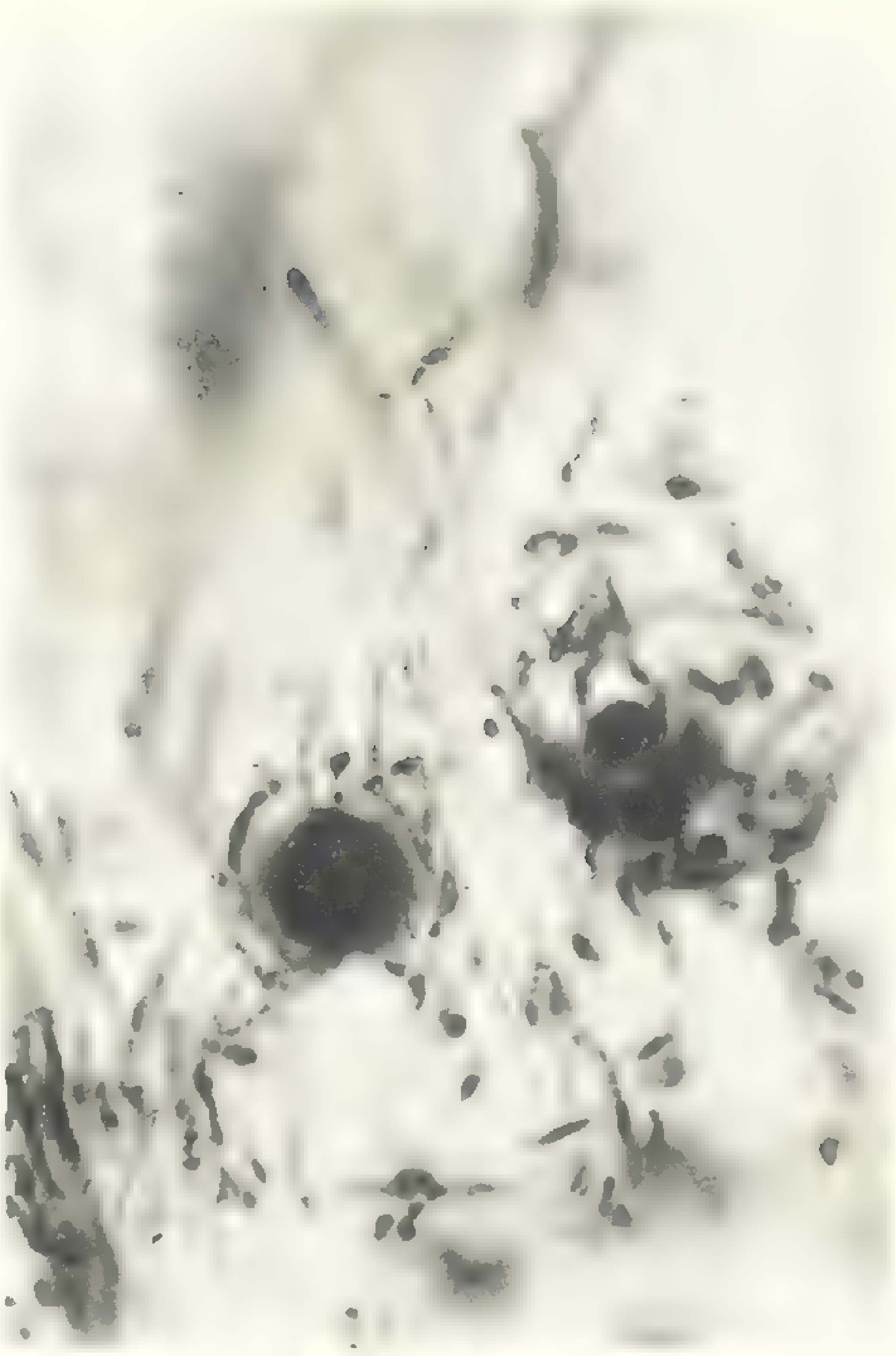

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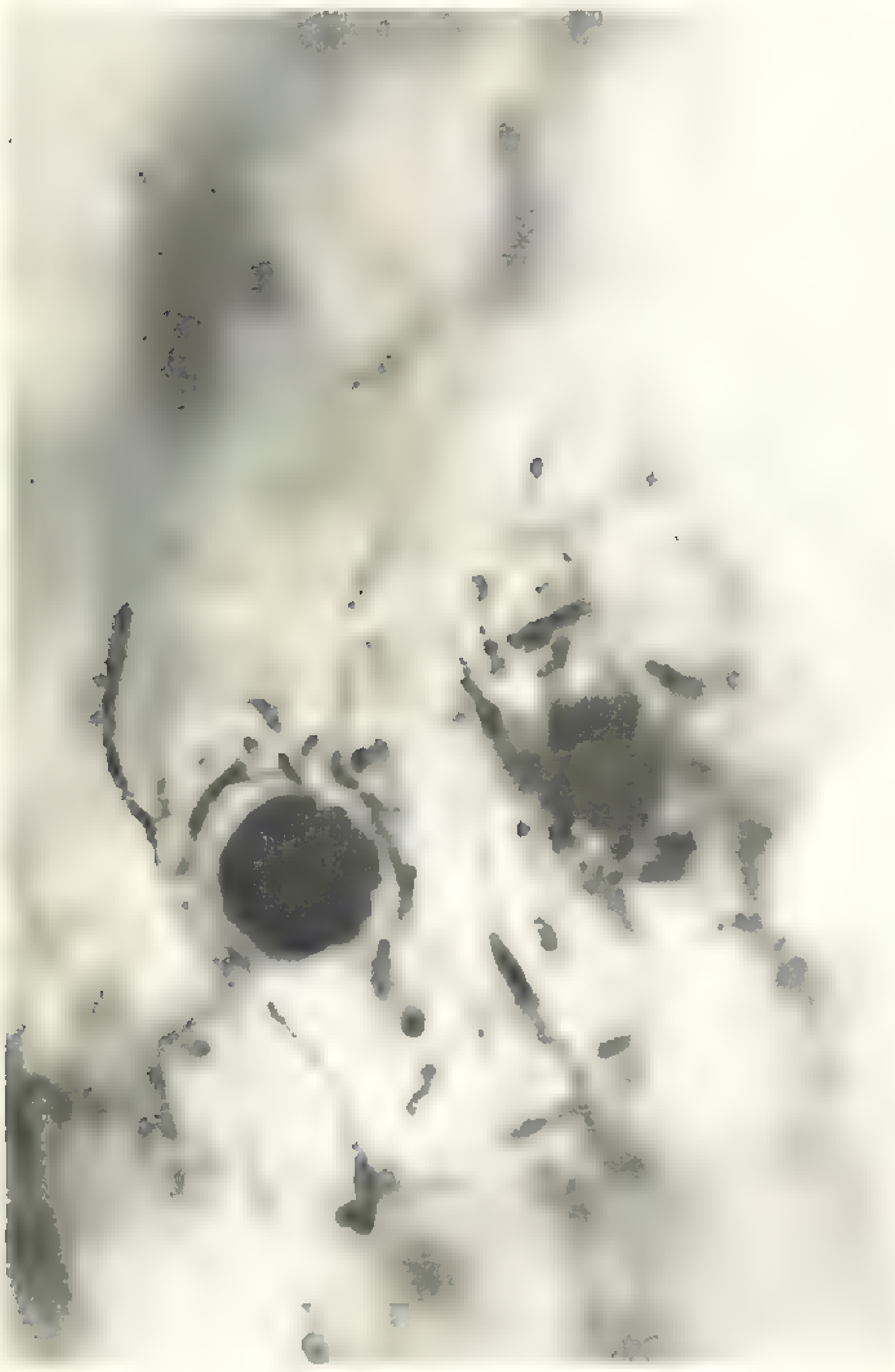

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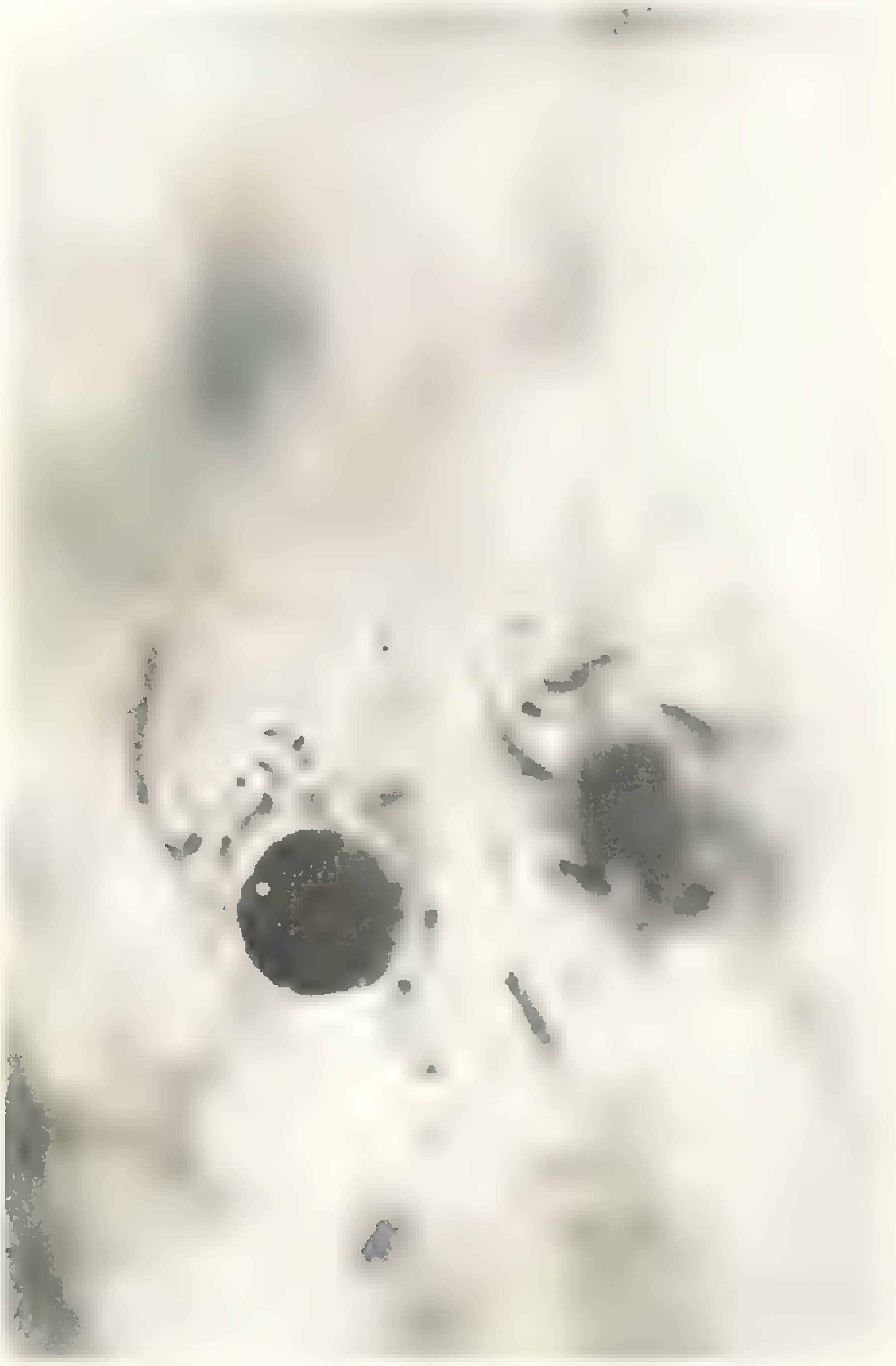

4

CLADONIA DIGITATA

On the External Morphology of the Stems of *Calamites*, with a Revision of the British Species of *Calamophloios* and *Dictyocalamites* of Upper Carboniferous Age. By E. A. NEWELL ARBER, M.A., Sc.D., F.L.S., and F. W. LAWFIELD, B.A.*

(PLATES 23–25.)

[Read 7th November, 1918.]

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1. *Introduction.*

IMPRESSIONS or casts of the external features of Calamite stems are still very little known in comparison with the pith casts of the same plants. As fossils they are not only much rarer but usually more fragmentary than the medullary casts, and for this reason little attention has been paid to them hitherto. Examples of external impressions of these plants have been figured from time to time by various authorities, including Stur †, Weiss ‡, and Solms §, and, in quite recent years, especially by Jongmans ‖ and Kidston ¶.

In all four of the large monographs which we now possess on the Calamites by Stur, Weiss, Kidston, and especially Jongmans, by far the greater number of the figures relates to pith casts. As a rule examples of both medullary casts and impressions showing the true external features of the stem are mixed together in confusion and are all referred to a common genus—*Calamites*. Neither from the generic nor the specific names employed, can one distinguish whether one is dealing with pith casts or with the rarer external surfaces of these stems.

In the largest and most recent monograph of this genus, that by Kidston

* Owing to the death of Dr. Arber the final revision of this paper has devolved entirely upon the junior author.

† Stur (1887). ‡ Weiss (1876) (1885). § Solms (1891) p. 317.

‖ Jongmans (1911), Jongmans & Kukuk (1913).

¶ Kidston & Jongmans (1915).

and Jongmans*, an advance copy of the text of which we have had an opportunity of studying, thanks to the kindness of Dr. Kidston, the same arrangement still holds, though here for the first time a systematic attempt is made to discriminate between the two forms of preservation.

It is hardly necessary, however, to point out that incrustations of the external features of the stems of these plants are of an entirely different morphological nature from the medullary casts. It was for this reason that the senior author† of the present paper proposed, in 1916, a new form genus *Calamophloios* for their reception, with the exception of the very distinct type *Dictyocalamites* ‡. There are also other considerations to which we shall refer more fully at a later stage (p. 513) which lead us to adopt these genera here, though as will be seen they admittedly involve some difficulties as regards the specific nomenclature.

In the present paper we are concerned rather with the morphology than the taxonomy of these fossils, though since our conclusions on the latter point differ somewhat from those of Kidston and Jongmans in their recent work (1915), we have added a short systematic revision of the British members of these genera which are best known to us. The synonymy of these types is pure in the sense that it excludes all examples which are simply pith casts or at any rate not incrustations of the true external surface.

We take this opportunity of expressing our thanks to Dr. Kidston for the negative of one of the figures here reproduced.

2. *The External Morphology of Calamite Stems.*

It may perhaps be well to commence our study of the external morphology of Calamite stems by some brief reference to the pith casts, the characteristics of which are now, in the light of petrified material, very thoroughly understood. Pith casts always show the following features :—

1. *Nodes* or constrictions of the stem at regular or irregular intervals.
2. *Internodes* or intervals between nodes. These may be long as compared with their breadth or *vice versa*, regular or irregular in size, or again periodic in the arrangement of a series of longer or shorter internodes.
3. *Internodes ridged and grooved.* The ridges may be of all degrees of fineness or coarseness, sharp or flat, broad or narrow. In most Calamites the ridges of one internode alternate in position with those of the internodes next above and below.

   In addition, true pith casts, as opposed to sub-medullary casts, may show :

4. *Infranodal canals.* Small prints, formed by the openings of infranodal canals into the pith, one on each rib just below the nodal line.

* Kidston & Jongmans (1915). † Arber (1916). ‡ Arber (1912).

5. *Branch scars.* These may or may not be present. Where they occur, they are situated just above the node.

   Three types of pith casts may be distinguished by the presence or absence of branch scars, and their distribution :

   (a) *Eucalamites*: branch scars occur on every node.

   (b) *Calamitina*: branch scars occur in periodic whorls, each branch-bearing node being separated from the next by a variable number of nodes without branch scars.

   (c) *Stylocalamites*: branch scars absent, or rare, or irregular in distribution.

It has also been pointed out by one of us* that sub-medullary casts are frequent among Calamites. The surfaces of these casts do not represent the periphery of the pith, but a more external region within the secondary wood. These sub-medullary casts are characterised by very broad ribs corresponding to the medullary rays and by the absence of infranodal scars. Since they represent a region external to the pith, they naturally do not show the prints of the openings of the canals into that region. Such sub-medullary casts are specifically indeterminable.

Specimens have also been figured by various authors which show the impression of the secondary wood, and which are neither medullary nor external casts. These need not detain us here. Such examples are easily recognised by the absence of nodes, though in Eucalamitean types one row of branches passing outwards clearly indicates the position of these regions.

On the other hand, casts or impressions of the external features of the stems of Calamites show the following characters :—

1. *Nodes.* It is imagined that these correspond in position to the nodes of the pith, though this fact has not yet been demonstrated. Petrifactions are almost silent on the subject of the external features of Calamite stems, since petrified Calamites have so far proved to be almost always decorticated, except in the case of very young twigs.
2. *Internodes*, which may be smooth or longitudinally striated, or partly smooth and partly ridged.
3. *Leaf scars* occurring on the node and representing the points of attachment of the leaves. These, however, are by no means always present.
4. *Branch scars*, which may or may not be present, and which if they occur follow the same types of distribution as are met with in pith casts. (See p. 512.)
5. Other features are *root scars*, frequently present on the nodes, and also in some cases scattered over the surface of the internodes.

We now propose to consider these features more in detail.

* Arber (1918).

Nodes.—The nodes of the external surface of *Calamites* vary somewhat in prominence. In many species they appear to be of the nature of constrictions or shallow grooves, as for instance in the examples of *C. britannicus* and *C. congenius* and other types figured here (*cf.* Pl. **23**. figs. 1 & 2). In other cases the nodes appear to be strongly salient, especially in the case of those nodes which bear branch scars, e. g. *C. Sachsei* (Pl. **24**. fig. 16) and *C. verticillatus* (Pl. **24**. fig. 18).

Internodes.—The specimens figured on Pls. **23–25** are chosen primarily to exhibit the characters of the internodes in different types, and are not intended to represent the features of all the specimens of the external surfaces of Calamites known to us.

In studying the external features of Calamites one difficulty in particular is always present. It is often not easy to decide whether the features exhibited by a particular specimen represent a truly external surface or a somewhat decorticated example. It may in fact be found, when better and further examples of some of the types here described are available, that we have mistaken sub-cortical surfaces for the true external surfaces. Thus in the case of some species in which, on the present evidence, we are inclined to think that the external surface was distinctly ribbed and not smooth, it may eventually prove, when better specimens have been obtained, that we have been mistaken in this respect. For the same reason we have perhaps maintained a larger number of species than will eventually be admitted by other workers. With regard to the terminology, we propose, for the sake of convenience, to speak of the more internal surfaces as sub-cortical. It is quite clear from our knowledge of the petrifactions of Calamites that the features with which we are concerned here are connected with the marked activity of a cork cambium. In fact they are, whether truly external or sub-cortical, botanically of the nature of cork, either periderm or, more probably, phelloderm.

It must also have been the case in regard to these trees, especially the older examples, that the outer corky layers were frequently exfoliated: or else destroyed by decay before preservation. In many cases, however, we think that the true external corky layer is still present.

In perhaps the majority of species of *Calamophloios* known to us the epidermal surface appears to be smooth, but it is nearly always possible to recognise by means of a lens a sub-cortical surface beneath, which is longitudinally striated—the striæ being usually fine, continuous or discontinuous. This is the case in *C. britannicus* (Pl. **23**. fig. 1), *C. rugosus* (fig. 3), *C. Sachsei* (Pl. **24**. fig. 16), and *C. undulatus* (figs. 14, 15, and 17). This minute striation also occurs in the case of the foreign species *C. ohlsbachensis* (Sterzel) * and *C. dictyoderma* (Kidst. & Jongm.) †. In other types the

* Sterzel (1907) p. 435, pl. 67. figs. 1, 1*a*–1*c*.

† Kidston & Jongmans (1915) p. 50, pl. 50. figs. 1 & 2.

external surfaces of the internodes appear to be strongly striated longitudinally, especially in the case of *C. majus* (Pl. **23**. figs. 5, 7, and 9) and *C. verticillatus* (Pl. **24**. fig. 18).

This ribbing is even more marked in the foreign species *C. Parrani* (Grand' Eury)*.

In the case of *C. congenius* (Pl. **23**. fig. 2) we appear to have a quite unique type so far as Britain is concerned, in which the internode has two distinct regions: a central, with a smooth external surface, and a sub-nodal, above and below the central area, in which the internode is strongly striated longitudinally. The same feature is also seen in the foreign specimen *Calamodendron striatum* of Renault †, and in some examples of *C. multiramis*, Weiss ‡.

In the case of *C.* (*cruciatus*) *Försteri* of Sterzel † the internodes between the nodal regions are not smooth, but are finely striated. The internodes are also, here, much longer than in *C. congenius*.

Beginning with those cases in which the external surfaces of the internodes are smooth, in the sense that they are not longitudinally striated, we have but few examples in which the surface is not relieved by ornamentation in some form or other. In the case of *C. Suckowi* (Pl. **24**. figs, 11–12) the surface is smooth and featureless, but faint sub-cortical striations can be recognised. In the undetermined specimen shown on Pl. **24**. fig. 19, which may possibly represent the external surface of *Calamites Cisti*, the surface is smooth with a delicate sub-cortical ribbing. In other species the bark is ornamented, as it were, in various ways. Sometimes large and well-marked cracks, or shallow grooves, essentially short and irregular, and disposed in various directions, are present. The finer examples of these grooves may be distinguished as wrinkles.

For instance, in *C. britannicus* (Pl. **23**. fig. 1) there are two series of these furrows or wrinkles, the greater part of the internodes being wrinkled transversely, whereas below the node there is a series of short vertical grooves. In *C. rugosus* (Pl. **23**. figs. 3 and 6) the ornamentation is delicate, and though characteristic is somewhat difficult to describe, the surface of the internode being faintly rugose with numerous crowded irregular shallow pittings. In the case of *C. paleaceus*, Stur §, the surface of the internode appears to us to be almost identical.

In *C. Goepperti* (Pl. **24**. fig. 13) one of the features by which this species can be readily recognised is the presence of a number of vertical continuous or discontinuous deep cracks or furrows in the bark, the grooves being

* Grand' Eury (1890) p. 211, pl. 14. figs. 6–8.

† Renault (1890) [in Renault & Zeiller (1888)] p. 457, pl. 54. fig. 5.

‡ Kidston & Jongmans (1915) pl. 114. fig. 1, pl. 117. fig. 1, pl. 127.

§ Sterzel (1893) p. 59, pl. 7. figs. 5 & 6, pl. 8. figs. 1–3.

|| Kidston & Jongmans (1915) pl. 155. figs. 2–3.

unequally spaced. This feature is also seen in the foreign types *C. macrodiscus* Weiss *, and *C. Germarianus* (Goepp.) †.

In *C. undulatus* (Pl. **23**. fig. 4, Pl. **24**. figs. 15, 17) there are numerous discontinuous grooves or wrinkles, mostly transversely disposed.

These are the chief types of surface ornamentation known to us, and they appear to be often of considerable taxonomic value.

With regard to the species in which the external surface of the internode appears to be longitudinally ribbed there is little that need be said. The ribbing varies considerably in its coarseness. In *C. majus* (Pl. **23**. figs. 5, 7, and 9, and especially Pl. **25**. fig. 22) it is markedly prominent; in *C. verticillatus* (Pl. **24**. fig. 18) the striations are also more or less strong and salient.

In the foreign type *C. pseudogermarianus* ‡ (cf. Pl. **25**. fig. 24) the ribbing appears to be less prominent. In *C. discifer* (fig. 23) the striations are very fine and close.

With regard to the sub-cortical striations, which can generally be recognised, they are usually fine and sometimes discontinuous; but in *C. britannicus* they are apparently fairly coarse.

We have here confined our attention almost entirely to the larger stems of *Calamites*. Smaller leafy branches, however, sometimes occur and have been figured by many authors, including Weiss. Some of these show nodal diaphragms. So far as our limited experience of the internodes of these smaller branches is concerned, they appear to be invariably smooth in surface.

Leaf scars.—In our experience leaf scars of species of *Calamophloios* are only rarely distinct. In some types, such as *C. congenius* (Pl. **23**. fig. 2) and *C. rugosus* (fig. 3), they are totally unknown. They are perhaps clearest in *C. Goepperti* (Pl. **24**. fig. 13) and in the foreign types *C. macrodiscus* § and *C. equisetinus* ‖. They are also fairly well seen in some specimens of *C. majus*. But we have observed no examples of the latter species in which they are as clear as in the Liverpool specimen, described a few years ago by Groom and Lewis ¶. We have, in fact, nothing to add to the account of these prints and their variation in shape and size as given by those authors. We may, however, remark that, as a rule, the scars are always approximated and chain-like in form.

Branch scars.—The branch scars on the external surfaces of the *Calamites* closely resemble those so well known on pith casts, and so far as we are

* Weiss (1884) p. 94, pl. 11. fig. 2.

† Kidston & Jongmans (1915) p. 79, pl. 69. fig. 2.

‡ Kidston & Jongmans (1915) pl. 64.

§ Weiss (1884) p. 94, pl. 11. fig. 2.

‖ Weiss (1885) pl. 1. figs. 1 & 2.

¶ Groom & Lewis (1912).

aware their distribution is the same in both cases. In size and shape the individual scars vary not only in different species of *Calamophloios* but in different specimens of the same species. As a rule, where the branch scars are approximated they are not all of exactly the same size. They appear to be typically quadrate in form with a central umbilicus. Where the scars in a whorl are crowded the form is sometimes more or less oval or circular. Among British specimens there are, so far as we are aware, no great differences as regards the shape of the branch scars, as there are, for instance, among certain foreign species, especially *C. semicircularis*, Weiss.

In many examples the limits of the branch scars are ill-defined or the details are obscure (cf. Pl. **25**. fig. 24).

Root scars.—The prints of root scars vary in size and are indefinite in shape. They are found both at the nodes and also in some cases scattered over the internodes (Pl. **23**. fig. 8, Pl. **24**. figs. 15, 20, Pl. **25**. fig. 21).

3. *The Correlation of Specimens exhibiting the external features of certain stems with their pith casts.*

We now come to consider the possibilities of correlating specimens showing the true external features of the stems of Calamites with the pith casts.

Although so little attention has been devoted to the former type of incrustation, we know already that this question presents more difficulties than might at first sight be imagined. It is especially in view of these facts that it has been regarded as necessary to erect the genus *Calamophloios*.

It is only quite rarely that the same specimen shows both the external surface of the stem and the pith cast. This is the case in the specimen of *C. undulatus* (Pl. **24**. fig. 15), the reverse side of which shows the pith cast, and in the two examples of *C. Suckowi* (figs. 11, 12) figured here.

As a rule, only one type of preservation is seen in a particular specimen. Supposing that type to be the external surface, can one be certain it always belonged to one particular type of pith cast, or *vice versa*? We think there is already evidence to show that this is not a safe assumption, and that the external surfaces of these stems frequently present stereotyped morphological features.

Dr. Jongmans* has stated that when studying *C. paleaceus*, Stur, he had become convinced that this species must represent the external features of *C. ramosus*. It was only when Dr. Kidston pointed out to him that this could not be the case, since the foliage and fructifications of these two Calamites are quite unlike, that he realised that the external surfaces of *C. paleaceus* and *C. ramosus* are practically indistinguishable.

Thus the name *Calamophloios rugosus* Arber, is here used as a type of

* Jongmans (1911) p. 122.

external surface which two distinct species of *Calamites* possess in common. Similarly it is regarded as probable that *Calamophloios Goepperti* as here defined is common to at least two types of pith cast, *Calamitina approximata* Brongn. (= *C. Schützeiformis*, Kidst. & Jong. forma *waldenburgensis*, Kidst. & Jong.*) and *Calamitina varians*, Sternb., but that it possibly does not include all the pith casts known under the latter name. Likewise all pith casts of the *Eucalamites cruciatus* type probably did not have the corresponding external features characteristic of *Calamophloios congenius* as here defined.

The problem is thus not so simple as it looks, and some elasticity in the nomenclature is necessary if it is to represent the known facts.

In general we have attempted to avoid adopting new specific names for the types of *Calamophloios* as compared with the pith casts, except where we know or suspect that stereotyping is markedly in evidence—as regards the external features. At the same time we think it possible that eventually a set of specific names entirely distinct from those of pith casts may be found necessary.

It may also be pointed out here, that a small difficulty arises as regards the nomenclature of *species*, if the same specific name is used for both types of preservation. Thus while a pith cast may be correctly designated as *Calamitina undulatus* (Brongn.), to call the corresponding external surface *Calamophloios undulatus* (Brongn.) would hardly be, strictly speaking, accurate, for there is no reason to believe that Brongniart himself knew of the *external surface* but only of the pith cast of this fossil. Strictly speaking it should be *Calamophloios undulatus* (Goode), since that observer first figured and described the external surface of this fossil. As, however, this method or that of supplying an entirely new name for each type (other than a pith cast) would tend to confusion on the one hand or a multiplicity of specific terms on the other, it seems, for the present at any rate, to be advisable where possible to retain the same specific name for both pith cast and its corresponding external surface. If the name of the authority in brackets after the species is taken to imply not merely a displacement of the genus but a definite emendation (which might, but need not, be written *emend.*), the system can perhaps stand.

With regard to the term *Calamophloios* itself it may be necessary to add a few words. A similar genus *Calamodendrofloyos* has already been used both by Grand' Eury † and Renault ‡ in much the same sense as *Calamophloios* here, though with a more limited application relating only to the

* Kidston & Jongmans (1915) p. 101.

† Grand' Eury (1877) p. 293.

‡ Renault & Zeiller (1888) p. 462.

external features of a particular type the pith cast of which is known as *Eucalamites cruciatus* (Sternb.). Grand' Eury's term, however, is not only cumbersome, but it can scarcely be retained now in view of the modern use of the word *Calamodendron,* as applied to one special *anatomical* type occurring among Calamites. The roots of the words *Calamites* and *Calamodendron* have an entirely distinct meaning, and thus *Calamophloios* appears to us to be preferable.

The following table represents a preliminary attempt to correlate the specimens of British Calamites showing the external surfaces, so far as they are described in the present paper, with their corresponding pith casts. We prefer to keep the genus *Calamites* as a natural genus for the whole plant and not to confine it to fragments of pith casts as a form genus. The form genera which we apply to the external surfaces of stems are *Calamophloios* and *Dictyocalamites*, while for the pith casts we prefer Weiss's terms, *Eucalamites*, *Stylocalamites*, and *Calamitina*, as representing three as natural types as can be expected to be distinguished among such fossils.

For further information on the correlation of other British and of foreign specimens the reader is referred to Kidston and Jongmans' Monograph *.

Correlation of the External Surfaces and Pith Casts of Calamites.

TYPES OF EXTERNAL SURFACE.	CORRESPONDING TYPES OF PITH CASTS.
Calamophloios britannicus (Kidston).	(Unknown).
Calamophloios congenius (Renault).	*Eucalamites cruciatus* (Sternb.) pars.
Calamophloios rugosus (Arber).	{ *Eucalamites ramosus* (Artis). { *Eucalamites paleaceus* (Stur).
Calamophloios Goepperti (Ett.).	{ ? *Calamitina approximata* (Brongn.). { ? *Calamitina varians* (Sternb.) pars.
Calamophloios majus (Feistm.).	? *Calamitina varians* (Sternb.) pars.
Calamophloios discifer (Weiss).	(Unknown).
Calamophloios Sachsei (Stur).	*Calamitina Sachsei* (Stur).
Calamophloios undulatus (Sternb.).	*Calamitina undulata* (Sternb.).
Calamophloios verticillatus (L. & H.).	? *Calamitina varians* (Sternb.) pars.
Calamophloios Suckowi (Brongn.).	*Stylocalamites Suckowi* (Brongn.).
(Unknown)? *cf.* Pl. **24**. fig. 19.	*Stylocalamites Cisti* (Brongn.).
Dictyocalamites Burri (Arber).	(Unknown).

* Kidston & Jongmans (1915).

4. *A Systematic Revision of the British Species of* CALAMOPHLOIOS *and* DICTYOCALAMITES.

Genus CALAMOPHLOIOS, Arber, 1916.

(Phil. Trans. R. Soc., Ser. B, vol. 208. p. 140.)

DIAGNOSIS. External surfaces of stems and branches of *Calamites.* Internodes smooth or striated. Striæ not reticulate.

Summary of British Species of CALAMOPHLOIOS.

1. *C. britannicus*, Weiss .... p. 516.
2. *C. congenius*, Arber .... p. 517.
3. *C. rugosus*, Arber .... p. 518.
4. *C. Goepperti*, Arber .... p. 518.
5. *C. majus*, Arber .... p. 520.
6. *C. discifer*, Arber .... p. 521.
7. *C. Sachsei*, Arber .... p. 521.
8. *C. undulatus*, Arber .... p. 522.
9. *C. verticillatus*, Arber .... p. 523.
10. *C. Suckowi*, Arber .... p. 524.
11. Miscellaneous specimens .... p. 525.

CALAMOPHLOIOS BRITANNICUS, Weiss MS. (Plate **23**. fig. 1.)

1888. *Eucalamites (Calamites) britannicus*, Kidston, Ann. & Mag. Nat. Hist. ser. 6, vol. ii. p. 131, pl. 7.

1909. *Calamites britannicus*, Arber, Foss. Plants, p. 73, fig. on p. 50.

1911. *Calamites britannicus*, Jongmans, Anleit. Bestimm. Karbonpfl. West-Europas, vol. i. p. 123, fig. 118 on p. 123.

1915. *Calamites britannicus*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. 7, p. 160, pl. 119. fig. 1; pl. 122. fig. 2.

DIAGNOSIS.—*Internodes* usually broader than long or of about equal length and breadth.

Bark with smooth surface, with shrinkage cracks or wrinkles. Cracks mostly transverse, short, deep; but in the region of the node the cracks are vertical, well marked, and short. Sub-epidermal surface striated longitudinally.

Leaf scars small, lenticular, approximated or slightly separated.

Branch scars elliptical or oval, several on every node, irregularly distributed, distant.

DESCRIPTION OF SPECIMEN.—The specimen figured on Pl. **23**. fig. 1, slightly reduced, shows two nodes, and a complete internode exceeding 10 cms. in length and about 6·5 cms. in height. The surface has the leathery transverse wrinkles which occur also in the case of other species, e. g., *C. undulatus.* There is also a series of short vertical grooves or bark cracks immediately underneath the node. One root scar is seen on the higher, and a branch scar on the lower node. The surface is quite smooth, and there is no sign of

sub-epidermal striation. Possibly where the epidermis is removed and the sub-epidermal structure revealed, the surface might be striated as appears to be the case in Kidston's type. The leaf scars are very indistinct in this specimen.

Small scars occur on the nodes which are probably root scars.

Distribution.

Middle Coal Measures—rare.

South Staffordshire ; Yorkshire.

CALAMOPHLOIOS CONGENIUS, Arber. (Plate 23. fig. 2.)

1890. *Calamodendrophloios congenius,* Renault, Flore foss. Terr. houill. Commentry, part 2, p. 464, pl. 56. fig. 3.

1893. *Calamites (cruciatus) septenarius* var. *fasciatus,* Sterzel, Abhandl. K. Sächs. Gesell. Wissen. (math.-phys. Classe) vol. xix. pp. 58, 75, pl. 8. figs. 4 & 5.

DIAGNOSIS.—*Internodes* very short, regular, 14–15 mm. long, much broader than long. Surface smooth, except on the borders of a node, where there is a small area, both above and especially below the node, in which the surface is strongly striated with very short striæ. Owing to the occurrence of branch scars the margins of these striated areas are sinuate.

Branch scars rounded or elliptical, small, many on each node, somewhat distant, alternating.

Leaf scars unknown.

DESCRIPTION OF SPECIMEN.—The specimen figured on Pl. 23. fig. 2, slightly reduced, is, so far as we are aware, unique from Britain. It was collected by one of us in 1905 from the Upper Coal Measures of the Somerset coal-field. Only part of the specimen—which exceeds 20 cms. in length—is shown in the photograph. It consists of a flattened stem with internodes about 6·5 cms. in width. The internodes are about 15–18 mm. in length and exceedingly regular. Each node bears many small oval branch scars, somewhat distant from one another. For an interval of about 5 mm., both above and below the node, the internode is slightly raised and is strongly striated. Between these striated regions the internode is smooth. The smooth area usually exceeds 1 cm. in length. Leaf scars invisible.

Remarks.—Kidston and Jongmans * include this type under *C. multiramis*, but in our opinion the British specimen figured here and the examples figured by Renault and Sterzel, as indicated in the above synonymy, are entirely distinct from the pith cast named *C. multiramis* by Weiss. It is clear that the characters attributed to the outer surface of this species by Kidston and Jongmans † are quite distinct from those of the present species.

* Kidston & Jongmans (1915) p. 171.

† *Ibid.* p. 172.

Sterzel * says that in his specimen leaf scars exist (Blattspuren vorhanden) and again that the leaf scars are indicated (angedeutet). We are, however, unable to see any trace of these organs in the British specimen.

Distribution.

Upper Coal Measures—very rare.

Radstock coalfield (Somerset).

CALAMOPHLOIOS RUGOSUS, Arber. (Plate **23.** figs. 3 & 6.)

1913. *Calamites ramosus* var. *rugosus*, Jongmans & Kukuk, Mededeel. R. Herbarium, Leiden, No. 20, p. 38, pl. 13. figs. 1–3.

1915. *Calamites carinatus* var. *rugosus*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. 7, pl. 41. figs. 1–3.

1916. *Calamophloios rugosus*, Arber, Phil. Trans. Roy. Soc. series B, vol. 208. p. 141, pl. 3. fig. 9.

DIAGNOSIS.—*Internodes* long, usually longer than broad, rugose, with crowded, irregular, shallow pittings. Also very faintly or (?) strongly striated longitudinally.

Branch scars, two on each node, very large with a very large central cavity, alternating in position.

Leaf scars unknown.

DESCRIPTION OF SPECIMENS.—The specimen figured on Pl. **24**. fig .3 shows a node with a fragment of a branch scar, and part of a long internode below. The surface of the internode is rugose, with numerous, crowded, irregular, shallow pittings. The rugose character is less marked here than in some other specimens. The sub-cortical surface is clearly striated longitudinally, as is seen immediately below the node. This ribbing is of the type met with in the pith cast of ?*Calamites Cisti* (see p. 525). A fragment of an internode of another specimen, showing the rugose surface more distinctly, is shown on Pl. **23**. fig. 6.

Distribution.

Transition Coal Measures—very rare.

South Staffordshire.

Middle Coal Measures—rare.

Derbyshire; Yorkshire; Kent.

CALAMOPHLOIOS GOEPPERTI, Arber. (Plate **24**. fig. 13.)

1854. *Calamites Goepperti*, Ettingshausen, Abhandl. k.-k. Geol. Reichsanst. Wien, vol. ii. part 3, No. 3, p. 27, pl. 1. figs. 3, 4.

1874. *Calamites verticillatus*, Williamson, Phil. Trans. Roy. Soc. vol. 164, pp. 66 & 80, pl. 7. fig. 45.

1875. *Calamitina Göpperti*, Weiss, Abhandl. Geol. Specialk. Preuss. vol. ii. part 1, p. 127, pl. 17. figs. 1 & 2.

* Sterzel (1893) p. 75.

1884. *Calamites* (*Calamitina*) *varians inconstans*, Weiss, Abhandl. Geol. Specialk. Preuss vol. v. part 2, pp. 62 & 69, pl. 16 A. figs. 7 & 8; pl. 25. fig. 2.

1884. *Calamites* (*Calamitina*) *varians abbreviatus*, Weiss, *ibid.* vol. v. part 2, pp. 62 & 73 pl. 16A. fig. 10.

1886. *Calamophyllites Goepperti*, Zeiller, Flore foss. Bassin houil. Valenciennes, p. 363, pl. 57. fig. 1.

1899. *Calamites varians*, Hofmann & Ryba, Leitpfl. p. 23, pl. 1. fig. 1.

1901. *Calamitina Göpperti*, Kidston, Proc. York. Geol. and Polytech. Soc. vol. xiv. part 2, p. 223, pl. 34. fig. 1.

1901. *Calamitina varians* var. *inconstans*, Kidston, *ibid.* p. 201.

1911. *Calamites Göpperti*, Jongmans, Anleit. Bestimm. Karbonpfl. West-Europas, vol. i. p. 82. figs. 81, 82.

1912. *Calamites* (*Calamitina*) *Goepperti*, Vernon, Quart. Journ. Geol. Soc. vol. lxviii. p. 622, pl. 57. fig. 10.

1913. *Calamites Goepperti*, Jongmans & Kukuk, Mededeel. R. Herbarium, Leiden, No. 20, p. 26, pl. 11. figs. 1–3; pl. 12. figs. 1–3.

1915. *Calamites Goepperti*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. 7, p. 51, pl. 51. figs. 3 & 4; pl. 53. figs. 1–3; pl. 54. figs. 1–3; ? pl. 55. fig. 2; ? pl. 56. fig. 3; ? pl. 61. fig. 3; pl. 65. fig. 1; pl. 66. figs. 1–3.

DIAGNOSIS.—*Length of internodes* very variable, 2–35 mm. Both very short and very long internodes occur. Internodes smooth or only very faintly striated longitudinally, but with distant vertical continuous or discontinuous deep cracks or furrows in the bark unequally spaced.

Leaf scars usually clear, prominent, oval, catenulate or even quadrate, 2–2·5 mm. broad, of medium size or even large, exactly approximated, with a punctate scar in the centre.

Branch scars of medium size or large, usually quadrate or circular or oval, often of unequal size and diameter, approximated, with a central umbilicus, 10 to 12 in a whorl. Internode bearing branch scars usually short. Periods very variable.

? *Root scars* occurring singly on nodes which do not bear branch scars.

DESCRIPTION OF SPECIMEN.—The specimen figured on Pl. 24. fig. 13, natural size, shows part of two periods, in which the internodes are very variable in length. The irregular longitudinal furrows or cracks in the bark are here clearly seen as they are still filled with the coaly matrix, but the surface of the internodes is perfectly smooth. The leaf scars are large, particularly prominent and regular.

Remarks.—Kidston and Jongmans include under this species a number of examples which we here regard as belonging to a separate species—*C. majus.* In *C. Goepperti*, according to our definition, the surface of the internodes is quite smooth, with the exception of the longitudinal cracks or clefts. In *C. majus* the internodes are clearly striated, often markedly so (see p. 520).

Distribution. Frequent.

Transition Coal Measures—rare.

Kent; ? South Wales; South Lancashire.

Middle Coal Measures—infrequent.
Kent ; Wyre Forest (North) ; Warwickshire ; Yorkshire.
Lower Coal Measures—very rare.
Yorkshire ; Ayrshire.

CALAMOPHLOIOS MAJUS, Arber. (Plate **23**. figs. 5, 7 & 9 ; Plate **26**. fig. 22.)

1874. *Cyclocladia major*, Feistmantel, Palæontogr. vol. xxiii. part 1, p. 96, pl. 1. fig. 8.
1884. *Calamites* (*Calamitina*) *extensus*, Weiss, Abhandl. Geol. Specialk. Preuss. vol. v. part 2, p. 87, pl. 4. fig. 2.
1889. *Calamitina* (*Calamites*) *varians* var. *inconstans*, Kidston, Trans. R. Soc. Edinburgh, vol. xxxv. part 2, p. 398, pl. 1. figs. 1 & 1*a*.
1911. *Calamites extensus*, Jongmans, Anleit. Bestimm. Karbonpfl. West-Europas, vol. i. p. 91, fig. 89 on p. 91.
1915. *Calamites Goepperti*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. 7, p. 51, pl. 55. figs. 1, 3, 4 ; pl. 56. figs. 1, ? 2, 4 ; pl. 81. fig. 4 ; pl. 135. figs. 1 & 2 ; pl. 136. fig. 1.

DIAGNOSIS.—*Internodes* strongly and coarsely striated longitudinally, very variable in length, often a little or distinctly shorter than broad. Periods 6–14, the shortest internode being above the branch-bearing node.

Branch scars of medium size, usually crowded, approximated, more or less quadrate, the angles sometimes rounded.

Leaf scars small, chain-like, oval, circular, or semi-circular, approximated.

DESCRIPTION OF SPECIMENS.—A large specimen, 7¾ cms. across, is seen half the natural size on Pl. **23**. fig. 5. Here there are more than five internodes in the period which is, however, incomplete. The internodes are broader than long and are distinctly striated longitudinally, the striæ being broad and flat. The leaf scars are only faintly preserved. The branch scars are rather small, crowded, and the branch-bearing internode is very short.

One or two internodes from a smaller specimen, 2 cms. across, are shown on Pl. **23**. fig. 7, enlarged 1½, to show the nature of the ribbing. The leaf scars are also indistinct here.

Part of a large stem, 11 cms. broad, is represented half natural size on Pl. **23**. fig. 9. It shows a node and three complete internodes. The latter are clearly striated longitudinally, as is seen from a part of one of the internodes shown natural size on Pl. **25**. fig. 22. The leaf scars are again indistinct.

Remarks.—Kidston and Jongmans * unite the specimens here termed *C. majus* with *C. Goepperti*. We, however, are inclined to maintain both species, for we have seen no conclusive evidence that the type here called *C. majus* is a partly decorticated example of *C. Goepperti*, which it must be if the two species are really identical.

* Kidston & Jongmans (1915) p. 56.

Distribution.

Middle Coal Measures—rare.

South Lancashire; Yorkshire; Derbyshire; Kent.

CALAMOPHLOIOS DISCIFER, Arber. (Plate **25**. fig. 23.)

1884. *Calamites* (*Calamitina*) *discifer*, Weiss, Abhandl. Geol. Specialk. Preuss. vol. v. part 2, p. 91, pl. 7. fig. 3.

1884. *Calamites* (*Calamitina*) *pauciramis*, Weiss, *ibid.* vol. v. part 2, p. 93, pl. 11. fig. 1.

1903. *Calamites* (*Calamitina*) *pauciramis*, Kidston, Trans. R. Soc. Edin. vol. xl. part 4, p. 789, pl. 4. fig. 36; pl. 5. fig. 44.

1911. *Calamites discifer*, Jongmans, Anleit. Bestimm. Karbonpfl. West-Europas, p. 106, figs. 102, 103.

1911. *Calamites pauciramis*, Jongmans, *ibid.* p. 105, fig. 101.

1911. *Calamites discifer*, Kidston, Mém. Mus. Roy. Hist. Nat. Belgique, vol. iv. p. 105, pl. 10. fig. 6.

1913. *Calamites discifer*, Jongmans & Kukuk, Mededeel. R. Herbarium, Leiden, No. 20, p. 33, pl. 14. figs. 2, 3.

1915. *Calamites discifer*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. 7, p. 75, pl. 58. fig. 4; pl. 61. fig. 4; pl. 62. fig. 3; pl. 65. fig. 2; pl. 67. figs. 2, 3; pl. 68. fig. 3; pl. 78. fig. 2; and text-figs. 41–44.

DIAGNOSIS.—Internodes of variable length, usually broader than long. Surface smooth, with very fine close longitudinal striations. Branch periods irregular. Branch scars of large or medium size, isolated, oval. Leaf scars circular, rather large, approximated.

DESCRIPTION OF SPECIMEN.—Part of a stem showing several internodes is figured natural size on Pl. **25**. fig. 23. This shows the surface of the internode and also a large branch scar. We are indebted to Dr. Kidston for this negative, which is taken from a specimen in his collection.

Distribution.

Middle Coal Measures—very rare.

Canonbie; Yorkshire.

CALAMOPHLOIOS SACHSEI, Arber. (Plate **24**. fig. 16.)

1884. *Calamites* (*Calamitina*) *varians Sachsei*, Weiss, Abhandl. Geol. Specialk. Preuss. vol. v. part 2, p. 77.

1887. *Calamites Sachsei*, Stur, Abhandl. k.-k. Geol. Reichsanst. Wien, vol. xi. part 2, p. 180, pl. 2. figs. 1, 3, 4 & 5; pl. 2 B. fig. 2; pl. 5. fig. 1: pl. 11. fig. 1.

1887. *Calamites schatzlarensis*, Stur, *ibid.* p. 164, pl. 13. figs. 10, 11.

1911. *Calamites Sachsei*, Jongmans, Anleit. Bestimm. Karbonpfl. West-Europas, vol. i. p. 89, figs. 87 & 88.

1913. *Calamites Sachsei*, Jongmans & Kukuk, Mededeel. R. Herbarium, Leiden, No. 20, p. 29, ? pl. 12. fig. 4.

1915. *Calamites Sachsei*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. 7, p. 60, ? pl. 56. figs. 5 & 6; ? pl. 57. figs. 1–3 & 7; pl. 58. figs. 1, 3; pl. 60. figs. 2, 3; pl. 62. fig. 1; ? pl. 63. figs. 4–6; ? pl. 66. fig. 4.

DIAGNOSIS.—Internodes smooth, with a faint and very fine longitudinal sub-epidermal striation. Internodes usually broader than long. Periods

usually short. Branch-bearing internodes short. Branch scars prominent, rather small or of medium size, quadrate, crowded. Leaf scars approximated, chain-like, small.

Description of specimen.—A fragment of a cast showing a very prominent branch-bearing node is seen on Pl. **25**. fig. 16, natural size. It also exhibits the smooth surface of the internodes.

Remarks.—This species is not very clearly marked off from *C. Goepperti*. According to Kidston and Jongmans* *C. Goepperti* is distinguished from *C. Sachsei* by its more circular and irregular branch scars and by the usually much shorter internodes.

Distribution.

Middle Coal Measures—very rare.

Wyre Forest (North); Derbyshire; Yorkshire; Durham.

Lower Coal Measures.

Lancashire; Fifeshire; Clackmannanshire.

Calamophloios undulatus, Arber. (Plate **23**. fig. 4; Plate **24**. figs. 15, 17, ? 14.)

1884. *Calamites* sp., Weiss, Abhandl. Geol. Specialk. Preuss. vol. v. part 2, pp. 22, 27, pl. 17. fig. 2.

1913. *Calamites undulatus*, Goode, Quart. Journ. Geol. Soc. vol. lxix. p. 262, text-fig. 2.

1913. *Calamites cf. undulatus*, Jongmans & Kukuk, Mededeel. R. Herbarium, Leiden, No. 20, p. 10, pl. 7. fig. 4.

1915. *Calamites undulatus*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. 7, p. 5, pl. 1. fig. 1; pl. 2. figs. 1 & 2; pl. 3. fig. 2; pl. 8. ? fig. 1; pl. 9. figs. 1-3; pl. 15. fig. 2; pl. 30. ? figs. 4 & 5.

Diagnosis.—Internodes with smooth surface with numerous transverse, discontinuous grooves or wrinkles. Sub-epidermal longitudinal striations, faint, very fine, ? discontinuous, sinuate. *Branch scars* rather small, elliptical or circular, approximated. *Leaf scars* markedly elliptical, approximated. *Root scars* of varying size, elliptical or circular, abundant both on nodes and ? the internodes.

Description of specimens.—Fragments of the external surface of two internodes are seen natural size on Pl. **24**. fig. 15. This specimen, which was originally described by Mr. Goode in 1913, is remarkable for the fact that it shows both the external surface and the pith cast of *C. undulatus*. The internodes are quite smooth with close, very fine, wrinkles. Several ? root scars are also seen on the internodes.

Another specimen is shown natural size on Pl. **24**. fig. 17. Here two nodes are seen, one of which bears a number of branch scars. The surface is again smooth, but there are numerous short, discontinuous, transverse grooves. The internodes also appear to be very finely striated longitudinally.

* Kidston & Jongmans (1915) p. 57.

the striæ being perhaps discontinuous, irregular and wavy. This feature is here possibly better seen than in the former specimen.

Another fragmentary specimen, possibly also belonging to this species, is shown natural size on Pl. 23. fig. 4. This again exhibits part of a branch-bearing node and two internodes. The transverse wrinkling of the latter is here more prominent than in the other specimens illustrated above. In this case the longitudinal striations are extremely faint.

The transversely elongated form of the leaf scars is here particularly prominent. The specific determination of this specimen is, however, somewhat doubtful.

Another specimen, also of somewhat doubtful determination but possibly *C. undulatus*, is shown natural size on Pl. 24 fig. 14. Two internodes are here seen, the surfaces of which have the same characters as in the specimens above described.

Remarks.—The question whether root scars can occur on the *internodes* of Calamite stems is a disputed one. In the specimen figured on Pl 24. fig. 15, as originally pointed out by Goode, there are scars on the *internodes*, which may possibly be interpreted as root scars. Similar specimens have been figured by other authors on several occasions, and these scars occur in the case of several species and also in *Dictyocalamites*. Kidston and Jongmans * regard these scars as due to some damage to the bark during the life of the plant. They add that "the position of these markings precludes the possibility of their being root scars." From this remark we infer that these authors only recognise as root scars those which are confined to the nodes. We are inclined, however, to regard these internodal scars as marking the position of adventitious roots, at any rate in some cases. Their occurrence is too common † for them to be explained as mere local imperfections of the bark. Until, however, roots are actually found attached, proof of this contention must remain lacking.

Distribution.

Middle Coal Measures—very rare.

Pembrokeshire ; Notts, and Derby.

CALAMOPHLOIOS VERTICILLATUS, Arber. (Plate 24. fig. 18.)

1835. *Calamites verticillatus*, Lindley & Hutton, Foss. Flora, vol. ii. pl. 139.

1886–1888. ? *Calamophylites verticillatus*, Zeiller, Flore Foss. Bass. houill. Valenciennes p. 360, pl. 57. fig. 2.

1893. *Calamitina verticillata*, Kidston, Trans. Roy. Soc. Edin. vol. xxxvii. part 2, p. 311, pl. 4. fig. 18.

1908. *Calamitina varians*, Renier, Rev. Univ. Mines, etc., series 4, vol. xxi. p. 42, text-fig. 17 on p. 42.

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* Kidston & Jongmans (1915) p. 13.

† Kidston & Jongmans (1915) pl. 55. fig. 2.

1910. *Calamites varians*, Renier, Doc. Étude Pal. Terr. houil. p. 17, pl. 45.
1911. *Calamites verticillatus*, Jongmans, Anleit. Bestimm. Karbonpfl. West-Europas, vol. i. p. 61, fig. 67.
1912. ? *Calamites* (*Calamitina*) *varians* var. *insignis*, Johnstone, Mem. and Proc. Manchester Lit. and Phil. Soc. vol. lvi. No. 17, pl.
1915. *Calamites verticillatus*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. 7, p. 71, pl. 51. ? fig. 2; pl. 52. ? figs. 3–5, 6 & 7; pl. 156. fig. 7.

DIAGNOSIS.—*Internodes* of variable length, strongly striated longitudinally. Striations more or less salient. Branch scars medium to large, circular, elliptic or quadrate, approximated, with a small umbilicus slightly eccentric. Leaf scars small rounded, quadrate, chain-like, approximated.

DESCRIPTION OF SPECIMEN.—The example figured on Pl. **24**. fig. 18, natural size, shows a number of internodes and a branch-bearing node. The nodes are distinctly tumid and the internodes are strongly ridged longitudinally; between the ridges are finer parallel striæ.

Distribution.

Middle Coal Measures—rare.
Yorkshire; Notts, and Derby.

Lower Coal Measures.
Ayrshire.

CALAMOPHLOIOS SUCKOWI, Arber. (Plate **24**. figs. 11–12; Plate **25**. fig. 21.)

1915. *Calamites Suckowi*, Kidston & Jongmans, Mededeel. Rijksopspor. Delfstoff. No. p. 111, pl. 85. fig. 2.

DIAGNOSIS.—*Internodes* usually broader than long. Surface smooth, with sub-cortical striations. Branch scars absent or very rare. Leaf scars small, distant, obscure.

DESCRIPTION OF SPECIMENS.—The specimen figured on Pl. **24**. fig. 11, natural size, appears to be the termination of a branch or rhizome. In the upper part the characteristic pith cast of *C. Suckowi* is seen, while below two internodes, showing external surface, are visible. The surface of these internodes is quite smooth, but there are longitudinal wrinkles and a very faint longitudinal and probably sub-cortical striation can be observed. Leaf scars are small, distant and indistinct.

Another specimen probably belonging to this species is figured on Pl. **25**. fig. 21, natural size. This shows four nodes, separated by smooth internodes which are, however, very faintly striated longitudinally. The leaf scars are again indistinct.

Another fragment, similar to that first described, is seen on Pl. **24**. fig. 12, somewhat enlarged. On the left-hand side the external features of the internodes are seen, while on the right the pith cast is exposed.

Distribution.

Middle Coal Measures—infrequent.

South Staffordshire ; Notts, and Derby ; Kent.

MISCELLANEOUS SPECIMENS. (Pl. **23.** fig. 10 ; Pl. **24.** fig. 19 ; Pl. **25.** fig. 24.) In addition, we have seen several specimens, some of which are figured here to show the external features of the internodes, but which, for one reason or another, we have not been able to identify specifically. One of these is shown somewhat enlarged on Pl. **23.** fig. 10. It is merely a fragment showing two nodes, one bearing branch scars. The internodes are smooth, with exceedingly fine, discontinuous and close longitudinal striations.

Another specimen is figured on Pl. **24.** fig. 19, natural size. The internodes are here fairly long, and the surface is smooth though also finely striated longitudinally. The leaf scars are chain-like and small, and not very distinct individually. We are inclined to regard this example as possibly the external surface of *Stylocalamites Cisti* (Brongn.), but the specific determination is uncertain. Another, somewhat exceptional specimen is shown natural size on Pl. **25.** fig. 24, which exhibits part of four internodes. One node shows two somewhat large branch scars, ill-defined as to their limits. The surface of the internodes is smooth, longitudinally wrinkled, especially near the node, and very finely striated longitudinally. The leaf scars are somewhat indistinct. This specimen has been doubtfully referred by Kidston and Jongmans * to their new species *C. pseudogermarianus.*

Kidston and Jongmans † have also recorded from Britain the following species showing external features of *Calamites,* of which we have seen no examples from this country :—

C. Wedekindi, Weiss.
C. semicircularis, Weiss.
C. dictyoderma, Kidst. & Jong.
C. ohlsbachensis, Sterzel.
C. Germarianus, Goepp.
C. Schützei, Stur.
C. jubatus, Kidst. & Jong.
C. paleaceus, Stur.

Genus DICTYOCALAMITES, Arber, 1912.

(Geol. Mag. dec. 5, vol. ix. p. 97.)

DIAGNOSIS. Stems or rhizomes, with internodes possessing reticulate striations. Roots or root scars numerous, nodal or internodal.

Remarks. When this fossil was first described from Britain, in 1912, no other similar example was known to us. We have since discovered that

* Kidston & Jongmans (1915) p. 85, pl. 59. fig. 4 etc.

† *Ibid.* (1915).

Stur * had figured, in 1887, a more complete specimen from the Schatzlarer Schichten in Silesia. This specimen will be further discussed below. It confirms the provisional conclusion arrived at from the Kentish species, namely that the fossil represents the external surface of a Calamite.

DICTYOCALAMITES BURRI, Arber. (Plate **23**. fig. 8; Plate **24**. fig. 20.)

1887. Cf. *Calamites Schultzi*, Stur, Abhandl. k.-k. Geol. Reichs. Wien, vol. ii. part 2, p. 73, pl. 6. fig. 2.

1912. *Dictyocalamites Burri*, Arber, Geol. Mag. dec. 5, vol. ix. p. 97, pl. 5. figs. 1, 3 & 5.

DIAGNOSIS.—*Internodes* somewhat variable in length, usually longer than broad. Surface smooth, with prominent, distant, reticulated grooved striæ, forming an elongate network with acute angles, the nodes usually longer than the internodes, reticulations bearing no relation in position to the node, or origin of the roots.

Root scars fairly large, irregularly oval on the nodes and internodes. Roots fairly stout, with fine and close transverse striations.

DESCRIPTION OF SPECIMENS.—The type specimen figured on Pl. **23**. fig. 8, nearly twice enlarged, shows the reticulate ridges of an internode and also root scars. Another fragment of the type figured on Pl. **24**. fig. 20, likewise nearly twice enlarged, shows a node and part of an internode, the latter having reticulate ridges and root scars.

Remarks.—We are not convinced that the Kentish specimens, which are fragmentary examples obtained from the cores of a boring, are specifically identical with Stur's plant. In the British examples the striations are somewhat closer and more prominent and grooved, the node is better defined, and the root scars are larger and more irregular.

In any case Stur's specific name can hardly stand, since under the name *Calamites Schultzi* he has also figured several pith casts, and there is no evidence that the particular specimen with which we are here concerned belonged to the same plant as the pith casts.

Stur states that the anastomosing striæ on his specimen are artificial and due to the fissuring of the coaly surface of the specimen. However this may be in the case of the Austrian example—and it appears to us to be very unlikely that Stur's explanation is correct—it is certainly not the case in the British fossil.

From Stur's figure one would imagine that this fossil may be a rhizome and not an aerial stem. This again must remain doubtful until further specimens of this rare fossil are available.

It may be also mentioned that according to Sterzel the sub-cortical surface of *Calamites ohlsbachensis* Sterzel † is reticulate.

Distribution.

Transition Coal Measures—Kent coalfields.

* Stur (1887) p. 73, pl. 6. fig. 2.

† Sterzel (1907) p. 437, pl. 67. fig. 1*b*.

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ZEILLER, R. See RENAULT & ZEILLER.

EXPLANATION OF THE PLATES.

(Some of the photographs require examination by means of a hand-lens. All the negatives were taken by Mr. W. Tams of Cambridge except Pl. **23**. figs. 1 & 2, which are by Dr. Arber, and Pl. **25**. fig. 23 by Dr. Kidston. All the specimens figured except Pl. **25**. fig. 23 are in the Carboniferous Plant collections, Sedgwick Museum, Cambridge, to which the numbers refer.)

PLATE 23.

Fig. 1. *Calamophloios britannicus*, Weiss. Showing the horizontal and vertical series of cracks or furrows in the smooth bark, and also root scars.

From the Middle Coal Measures of Barnsley, Yorks. No. 410. Slightly reduced. ($\times \frac{6}{7}$.)

Fig. 2. *Calamophloios congenius*, Arber. Showing the ridged regions of the internodes subtending the nodes and separated by areas with smooth bark. Many branch scars are also seen.

From the Upper Coal Measures, Lower Conygre Pit, Tinsbury, Somerset. No. 1363. Slightly reduced. ($\times \frac{5}{6}$.)

Fig. 3. *Calamophloios rugosus*, Arber. Showing the ornamentation of an internode and an indistinct branch scar.

Transition Coal Measures, Red Clay Series, Granville Clay Pit, Old Hill, South Staffordshire. No. 3322. (*Natural size.*)

Fig. 4. *Calamophloios undulatus* ?, Arber. Showing the transverse wrinkling of the internodes, the leaf scars and two branch scars.

Middle Coal Measures, Bonds Main Colliery, Temple Normanton, Derbyshire. No. 4011. (*Natural size.*)

Fig. 5. *Calamophloios majus*, Arber. A reduced photograph of a large specimen with several internodes, which are longitudinally ridged. A number of branch scars are seen on the second node above the base of the specimen.

Middle Coal Measures, Mattice Hill Boring, at 1680 ft., Kent. No. 2338. ($\times \frac{1}{2}$.)

Fig. 6. *Calamophloios rugosus*, Arber. Part of an internode showing the rugose ornamentation.

Middle Coal Measures, Clay Cross, Derbyshire. No. 3398. (*Natural size.*)

Fig. 7. *Calamophloios majus*, Arber. Enlarged view of internodes to show the ribbing. Branch scars are faintly seen at the summit of the specimen.

Middle Coal Measures, Ripple Boring, at 2666 ft., Kent. No. 2290. ($\times \frac{3}{2}$.)

Fig. 8. *Dictyocalamites Burri*, Arber. Enlarged photograph of type specimen showing the reticulate ridges of an internode and root scars.
Transition Coal Measures, Barfreston Boring, at 2559 ft., Kent. No. 2225. ($\times \frac{9}{8}$.)

Fig. 9. *Calamophloios majus*, Arber. Reduced photograph showing the ridged internodes and a whorl of branch scars.
Middle Coal Measures, Bonds Main Colliery, Temple Normanton, Derbyshire No. 3996. ($\times \frac{1}{2}$.)

Fig. 10. *Calamophloios* sp. Enlarged photograph showing the smooth internodes and a whorl of prominent branch scars.
Lower Coal Measures, Trowel Colliery, Notts. No. 3967. ($\times \frac{4}{3}$.)

Plate 24.

Fig. 11. *Calamophloios Suckowi*, Arber. The surface of the lower internodes is smooth, with a faint sub-cortical striation. Towards the upper end of the branch the characteristic pith cast of this species is exposed.
Middle Coal Measures, Newthorpe Clay Pit, Notts. No. 3994. (*Natural size.*)

Fig. 12. *Calamophloios Suckowi*, Arber. Enlarged photograph showing the external features of the internodes on the left-hand side and the pith cast on the right.
Middle Coal Measures, Newthorpe Clay Pit, Notts. No. 4005. ($\times \frac{3}{2}$.)

Fig. 13. *Calamophloios Goepperti*, Arber. Showing the smooth internodes with irregular vertical grooves, the leaf scars and a whorl of branch scars.
Middle Coal Measures, Summit Colliery, Derbyshire. No. 3992. (*Natural size.*)

Fig. 14. *Calamophloios undulatus* ?, Arber. Finely ornamented bark of two internodes.
Middle Coal Measures, Digby Clay Pit, Kimberley, Notts. No. 3993. (*Natural size.*)

Fig. 15. *Calamophloios undulatus*, Arber. Showing the ornamentation of two internodes and root scars.
Middle Coal Measures, Falling Cliff, Little Haven, Pembrokeshire. No. 2863. (*Natural size.*)

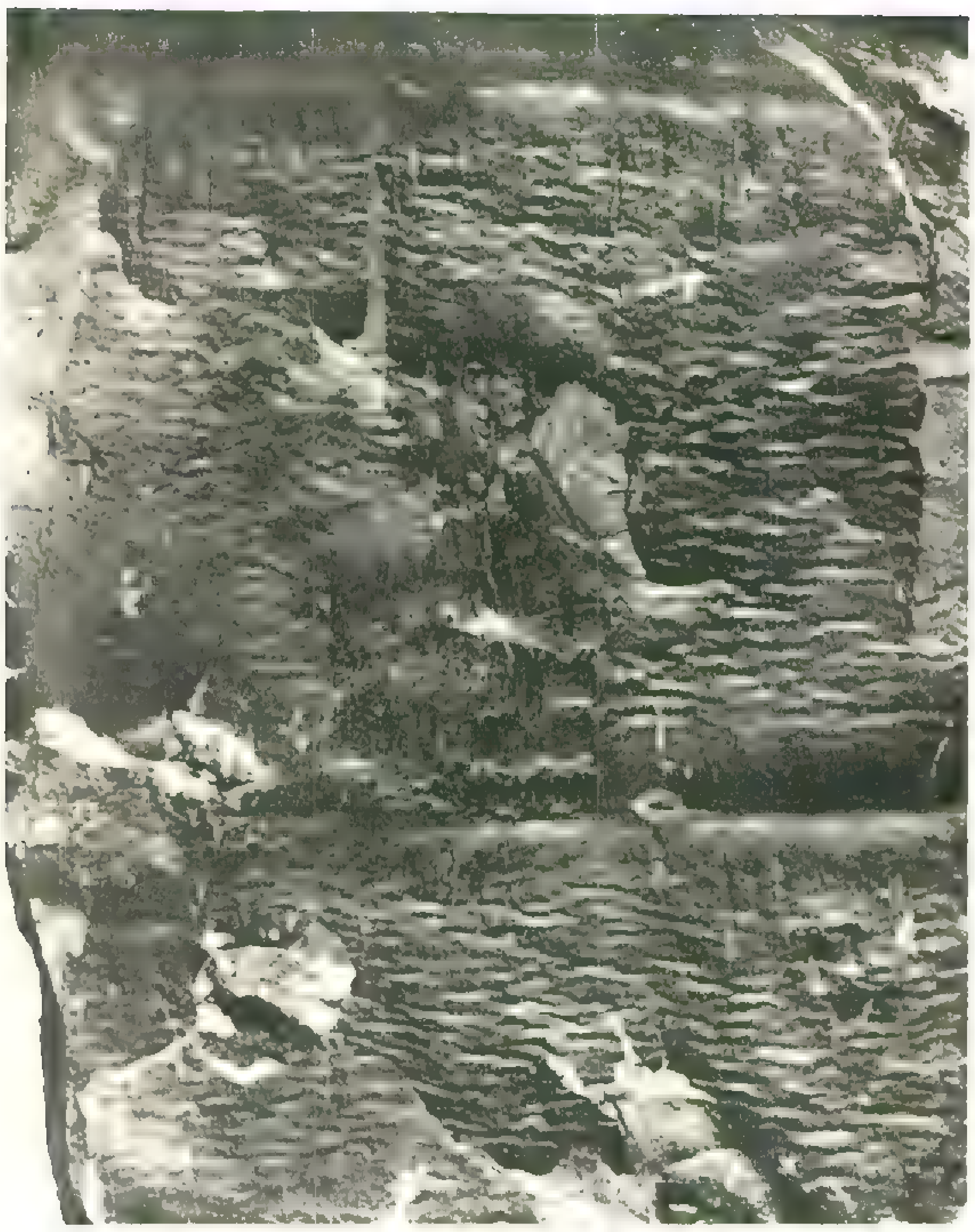
Fig. 16. *Calamophloios Sachsei*, Arber. Showing the apparently smooth internodes and a prominent whorl of branch scars.
? Middle Coal Measures, ? locality, Derbyshire. No. 1996. (*Natural size.*)

Fig. 17. *Calamophloios undulatus*, Arber. Showing the transverse furrows of an internode and a whorl of branch scars.
Middle Coal Measures, Bretby Clay Pit, Derbyshire. No. 3991. (*Natural size.*)

Fig. 18. *Calamophloios verticillatus*, Arber. Showing the longitudinally ridged internodes and a whorl of branch scars.
Middle Coal Measures, Newthorpe Clay Pit, Notts. No. 2736. (*Natural size.*)

Fig. 19. *Calamophloios Cisti* ?, Arber. Showing smooth internodes, with sub-cortical ridging. (Unfortunately turned upside down in reproduction.)
Middle Coal Measures, Mattice Hill Boring, at 1276 ft., Sandwich, Kent. No. 2339. (*Natural size.*)

Fig. 20. *Dictyocalamites Burri*, Arber. Enlarged photograph of the type specimen, showing a node and part of an internode with reticulate ridges and root scars.
Transition Coal Measures, Barfreston Boring, at 2559 ft., Kent. No. 2225. ($\times \frac{9}{8}$.)



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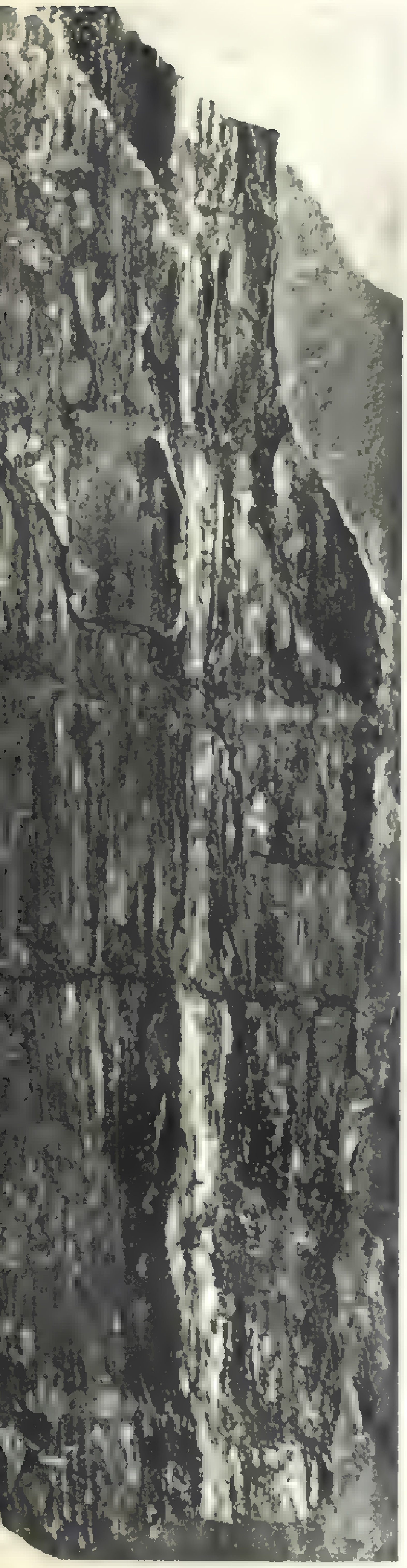
E.A.N.A. et W.Tams photo.

CALAMOPHLOIOS



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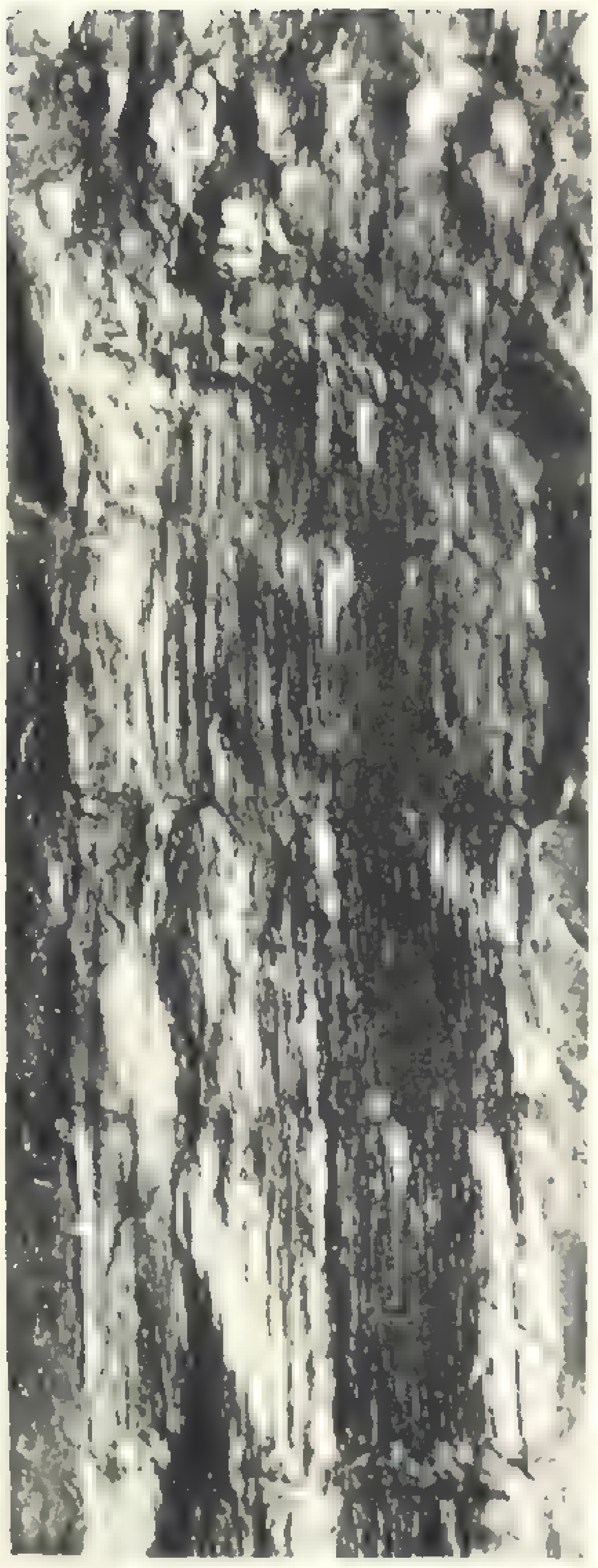

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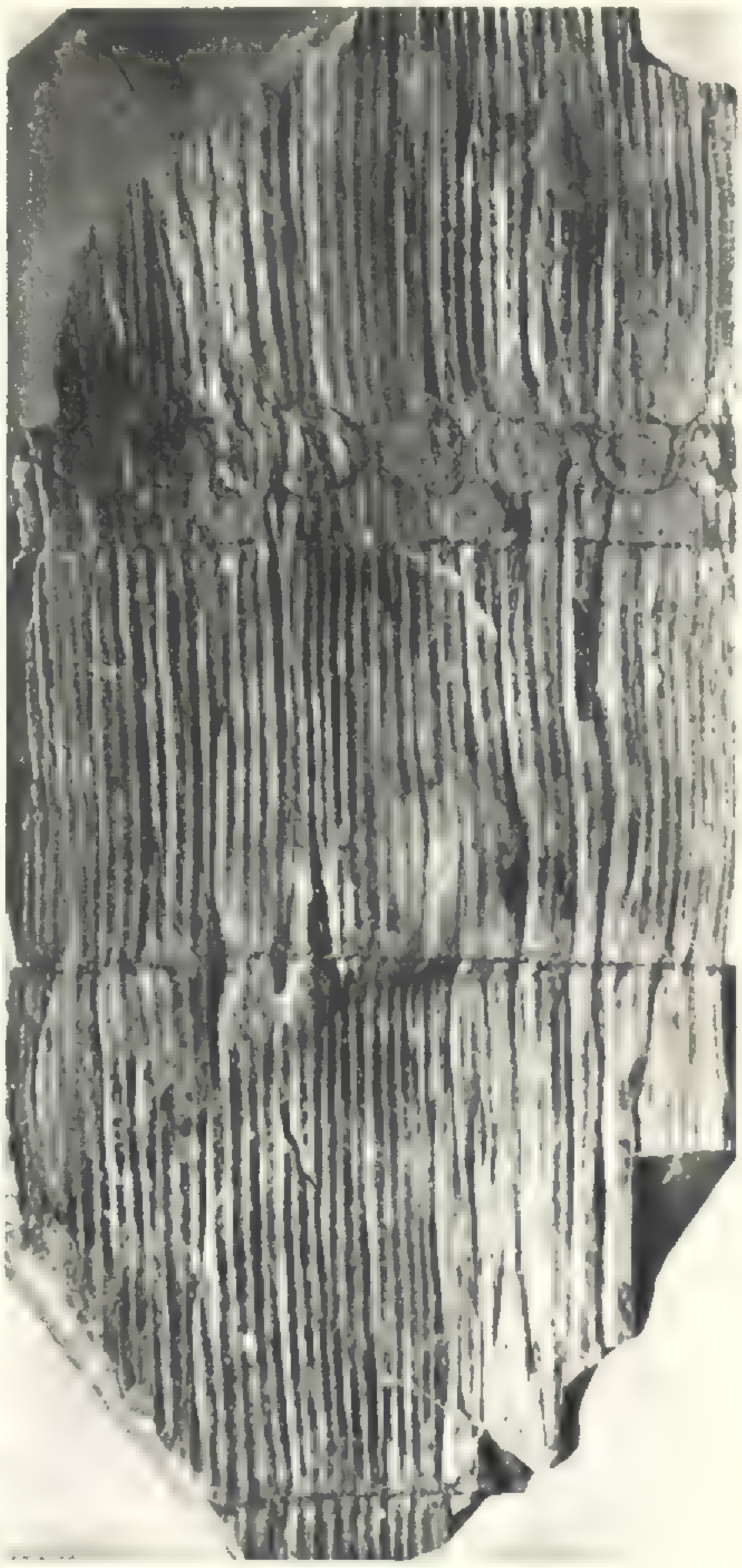

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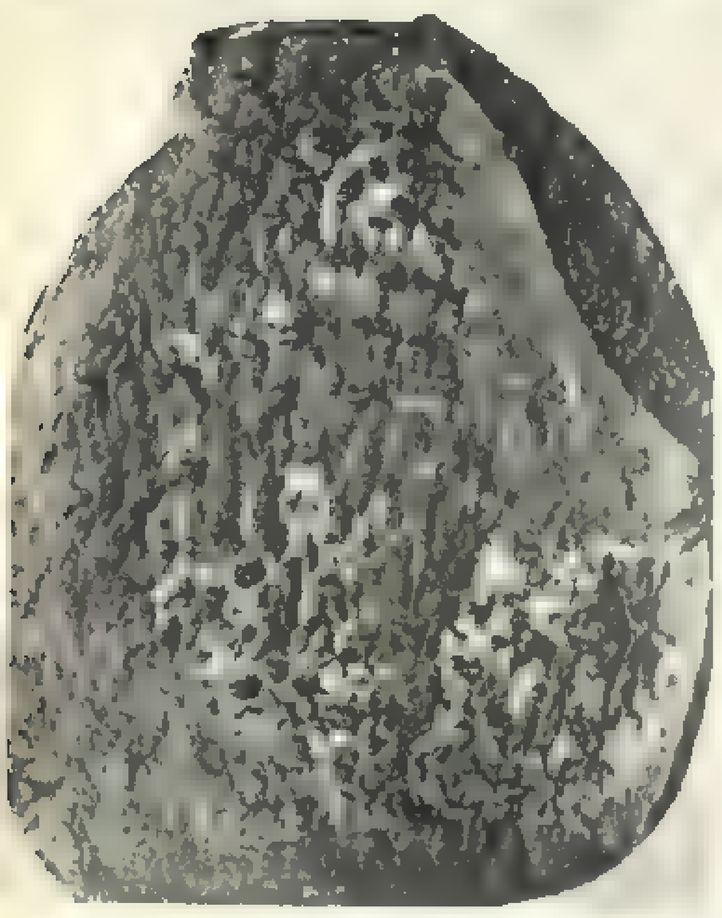

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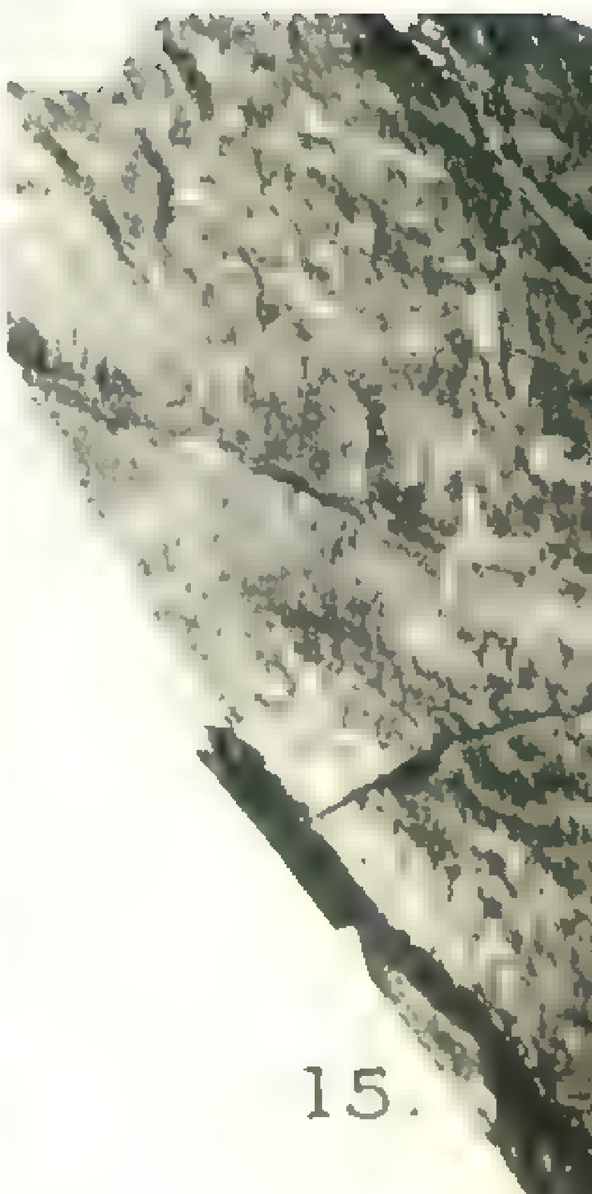

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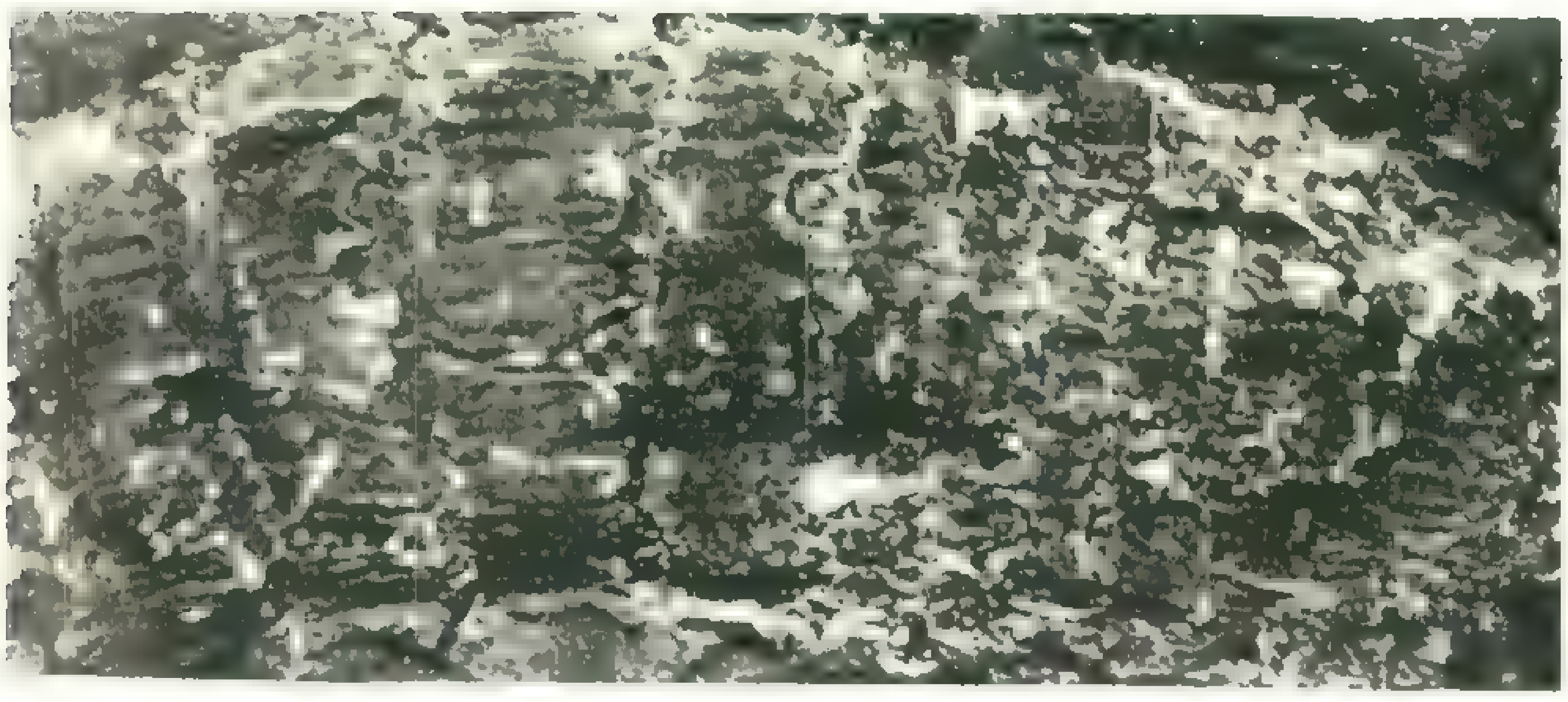

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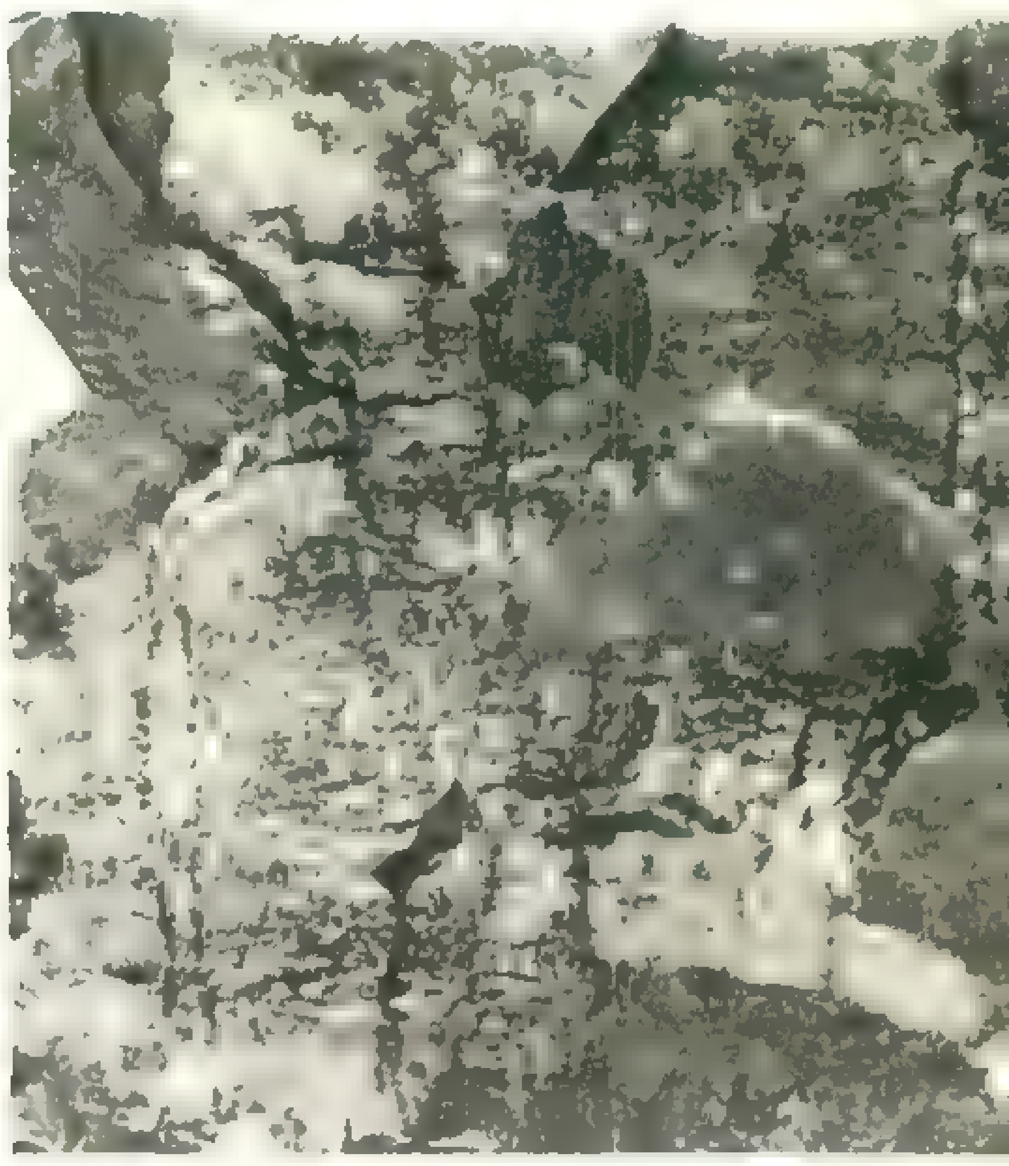

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CALAMOPHLOIOS

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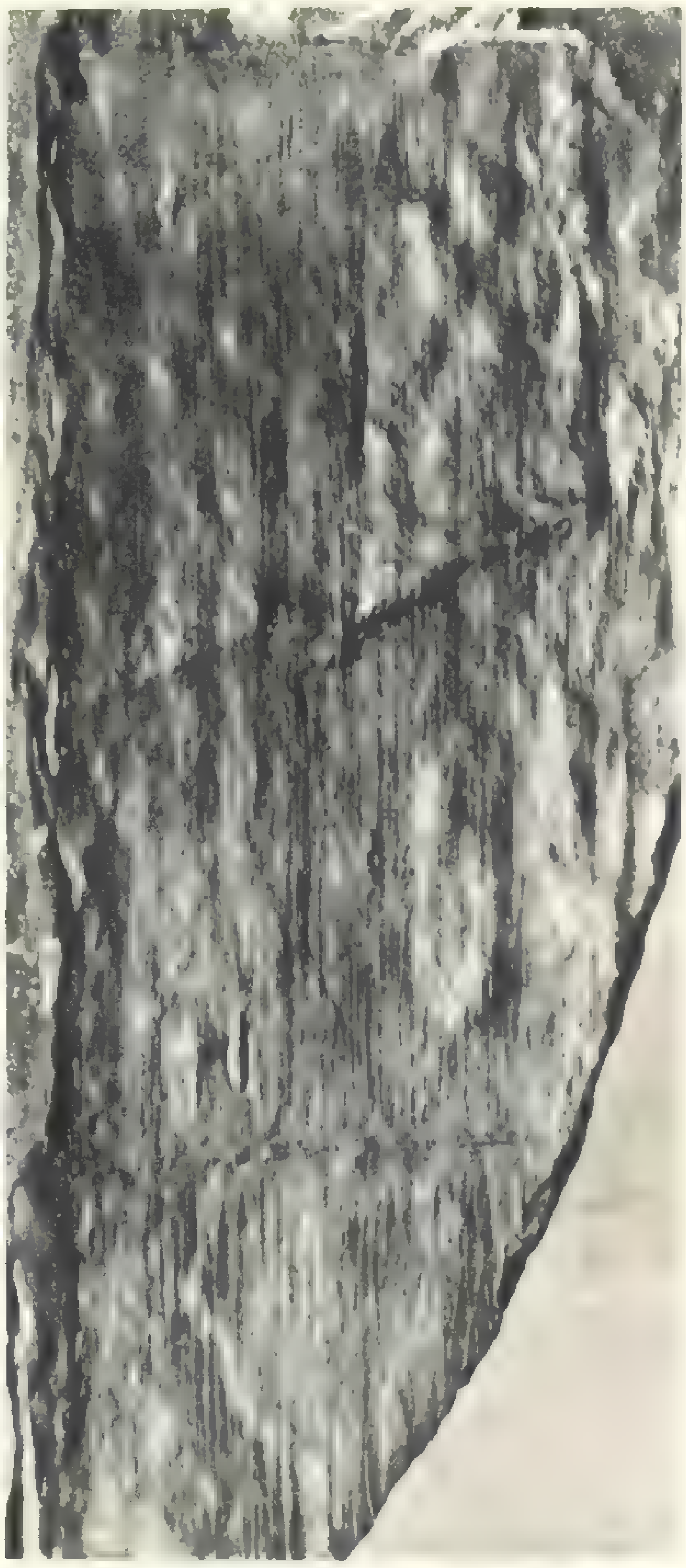

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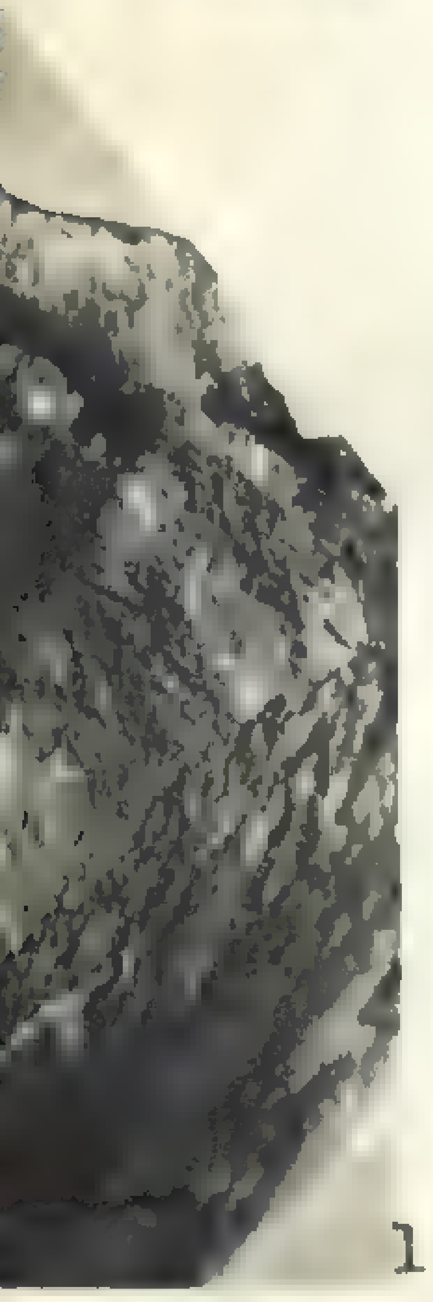

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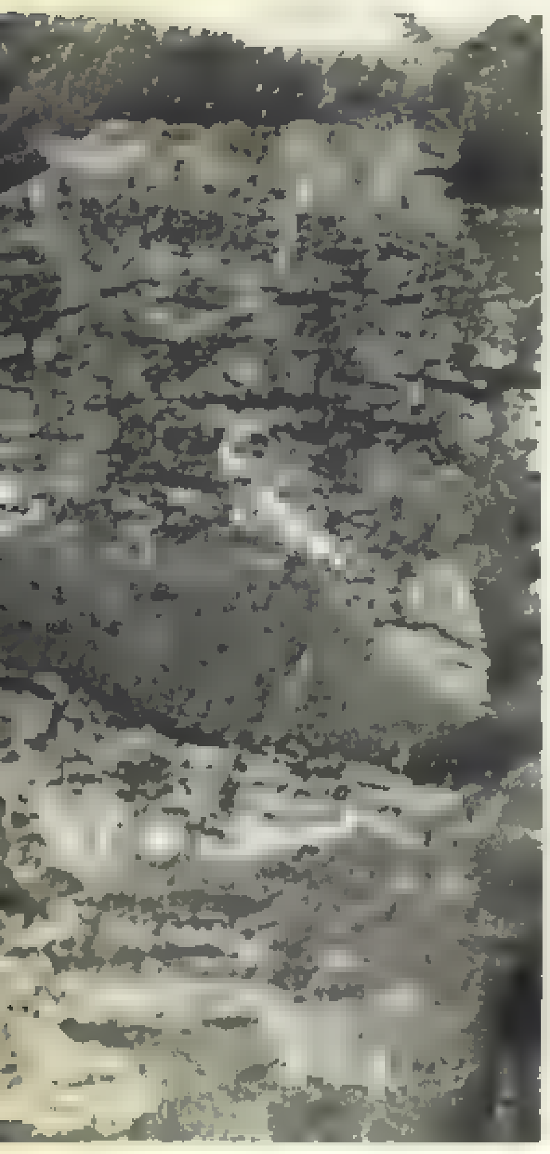

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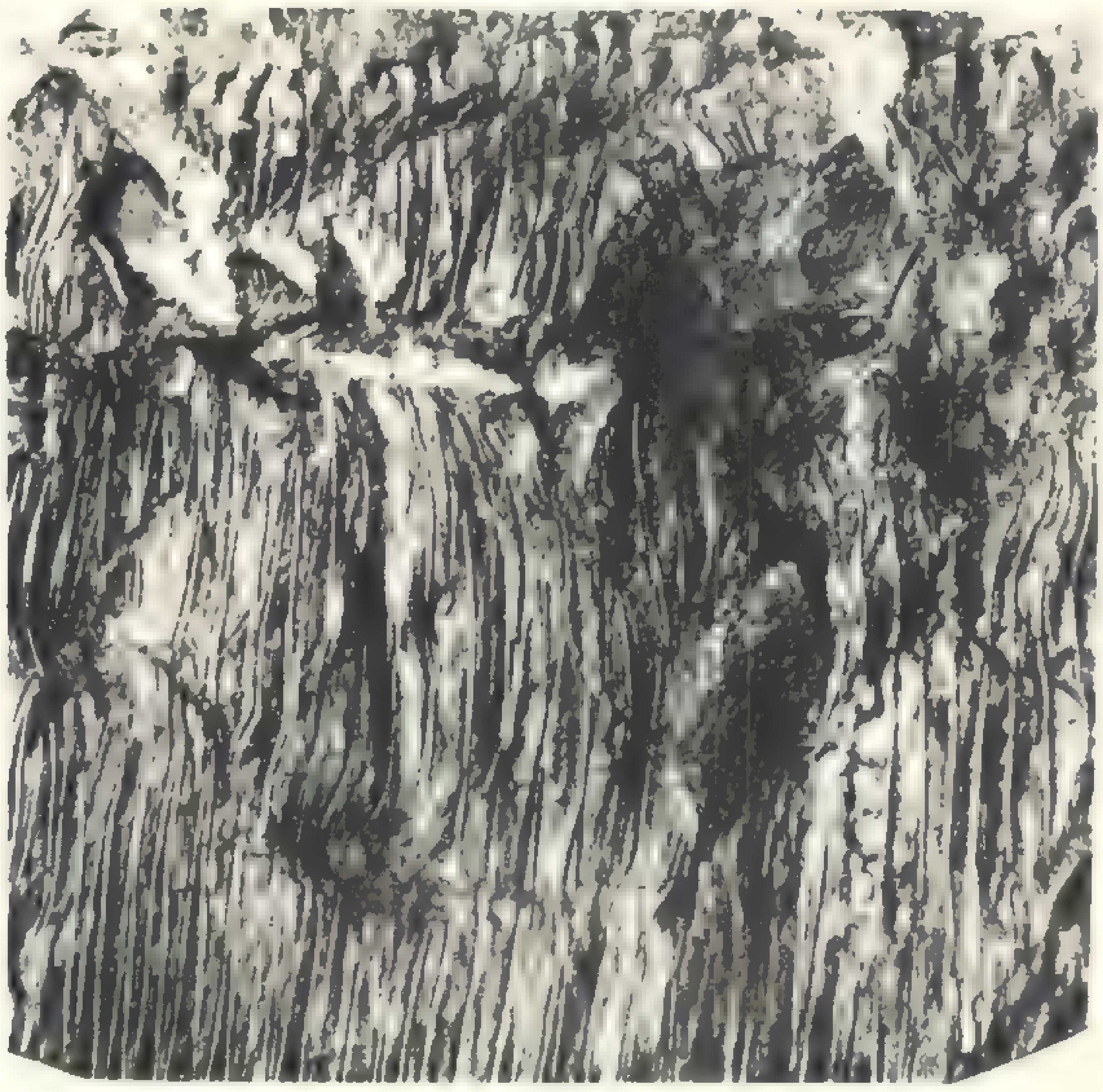

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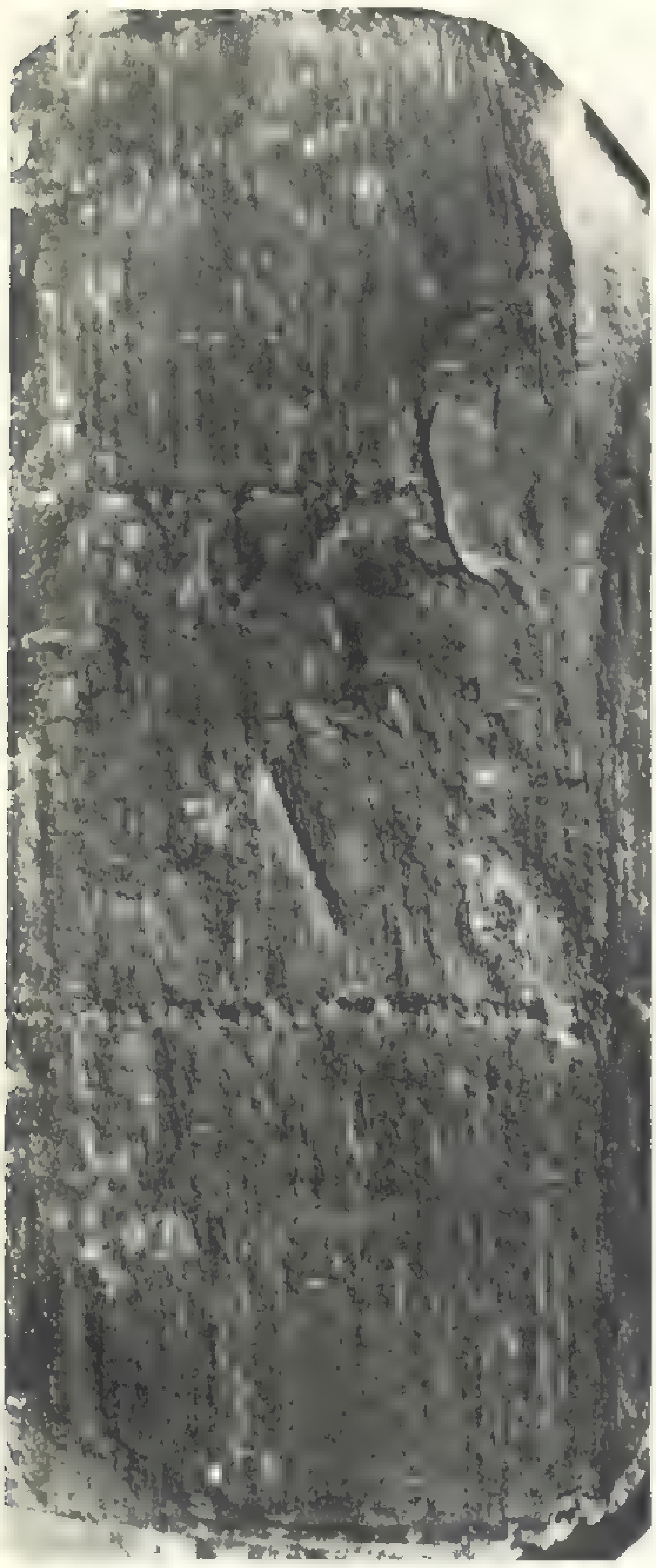
DICTYOCALAMITES.



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CALAMOPHLOIOS.

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